A COMPENDIUM OF FORESTRY PG SEMINARS

ACADEMIC YEAR
(2013-14 to 2017-18)

COLLEGE OF FORESTRY
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI- 396450

NAU / No. ACHF/ Forestry / ICAR/1431-45/ 2018

Compiled By

Dr. Manmohan J Dobriyal

Associate Professor &

P. G. Seminar Coordinator (Forestry)

College of Forestry, NAU, Navsari

Published By

Principal

College of Forestry

Navsari Agricultural University, Navsari

Financial support: This document is published with the financial support from the ICAR Development fund- 2017-18, ICAR New Delhi

March, 2018

Dr. B.N. Patel
Dean
Faculty of Forestry
Navsari Agricultural University

FOREWORD

Forestry education in India as a part of NARES began in 1985 in SAUs where as in Navsari Agricultural University under the aegis of ASPEE College of Horticulture and Forestry (ACHF), B.Sc. (Forestry) started in1988. M.Sc. Forestry teaching started in 1992 with specilaisation in Agroforestry later in 2006 added Ph.D Forestry programme with speciliastion Agroforestry and Ecology and further widended with addition of other speciliastion of Forest Genetic Resources, Forest products, NRM etc. Forests and trees are the major contributors for human welfare by providing diverse wood and non wood products as well as essential environmental services for survival of mankind. Development of technologies and recommendations related to forestry, agroforestry, medicinal plants, NRM and nursery/ propagation are essential for the productivity enhancement and diversification of Indian agriculture. Its being the only Forestry College under SAUs of the Gujarat, the responsibility and accountability for improvement and way ahead in field of forestry or agroforestry lies on the strong shoulders of the NAU foresters.

The first time current compilation of “A compendium of Forestry PG Seminars” is a good step to document the academic worth and knowledge generated by PG students and to have a ready material of reference for new PG students and faculty. This kind of regular documentation of information at institute level is hepful to analyse the the past topics and plan a improved version for future needs.

I congratulate the Principal, College of Forestry and P.G. Seminar Coordinator (Forestry) for compiling the “A compendium of Forestry PG Seminars” document for reference. I wish this document will fulfill the academic and practical use of all stakeholders, students, teachers and other academicians interested in the field of forestry.

(B.N.Patel)

Dr. P.K Shrivastava
Principal
College of Forestry
Navsari Agricultural University

PREFACE

The College of Forestry under the aegis of Navsari Agricultural University is one among the oldest forestry faculty imparting Forestry education undergraduate programme since 1988. Thereafter, Post graduate programmes leading to M.Sc. (Forestry) and Ph.D. (Forestry) degrees with Agroforestry specilisation commenced from 1992-93 and 2006-07, respectively. It has been spearheading forestry research, education and extension activities for promotion of forestry / agroforestry for productivity enhancement and diversification of Indian agriculture. In Forestry education within National Agricultural Research and Education System (NARES). The College has adopted ICAR's BSMA committee prescribed syllabus and also contributed in framing of the course curriculum. BSMA (Forestry), 2009 guidelines were adopted in 2010 in Forestry PG programme with M.Sc. Specilasation in 7 disciplines viz, Agroforestry, Planation Technology, Forest genetic resources, Forest Biotechnology, Medicinal & aromatic Plants, Wood Science & Technology and Watershed management. Similarly, Ph.D Forestry expanded with specilisation in Agroforestry, Forest genetic resources and Medicinal & aromatic plants. From academic year 2017-18 as per ICAR, Vth Deans endorsement the college has adopted department wise PG Forestry degree programme in 4 departments viz, Silviculture & agroforestry, Forest biology & Tree Improvement, Forest Products & Utilisation and Natural Resource Mangment.

College of Forestry which is the only institute in Gujarat for forestry is committed to development of tree based land used systems for livelihood, nutritional and environmental security at state and national level. Though, NAUs jurisdiction is in south Gujarat but College of forestry at NAU is a main stakeholder in matters related to forestry for the whole state of Gujarat. The college is committed to transform itself into an organization engaged fully with the forest department, tribals, farmers, industry, entrepreneurs and consumers at large. We are already operating number of research projects in field of forestry.

The present document "A compendium of Forestry PG Seminars" is a valuable document of the college as being being first ever compilation of scattered information. I congratulate and appreciate the efforts taken by Dr. Manmohan J Dobriyal, Associate Professor & P.G. Seminar Coordinator (Forestry) to prepare the compendium. I am hopeful that document will be helpful as a ready reference book for the academic and practical use of forestry faculty and students and other stakeholders interested in field of forestry.

(P.K. Shrivastava)

Verses of Credit Seminars

Post garudate education in professional courses of agricultural sciences is more intresting as it involved testing of aspects which already well explored and close not only to farmers but also common people. One way it is easy to understand but difficult to convince the theoretically as it directly linked to agriculture or forestry or natural landscape. Farming quotient (FQ) or farming intelligence (FI) is require to a optimum level to play with agricultural landscape. Similary in naural resources or forest sciences an equal level of connectivity and closeness is prerequisite to explore the new vistas of science. There are numerous topics, themes, micro themes/ aspects which still are unexplored or untested due to there vary nature existence. These all aspects can be reviewd, researched and compiled to give an insight of different natural science phenomenon and interaction of biological activity. Many times reviewing a new topic or aspects opens various dimnensions to work upon and catch the solutions. The curosity of discovering any new field is genesis of scientific temparament. Forestry is one such discipline which not just a biological science but an amalgamation of various aspects of physical, chemical and social sciences. Forest and people bonding is since the evolution of humanbeing as former being its saver. Later when man start domestication of crops and livestock, forests became foster mother of agriculture. Now the situation is alarmed with increase in population, depleting envrionment and eroding values of environmental ethics. The current compilation of Forestry PG seminar topics is one such verses which deal above mention surround and a glimpse of our efforts to reconcile ourselves by selecting such topics and presenting to the audience.

There are many things in the structured PG course currlicuum of ICAR to engage, knowledge and professionate a post gaudate students. In PG programmes other than regular assignments of the courses, the research and ceredit seminar has a special reference. Both research and seminar give first look with their title and theme which act as teaser for rest of the presentation.The selection of topic, collection of contents, reviews, arranging the contents in a continum of theme, analyzing the reviwed papers, preparing the audio visuals tamplets and finally presenting to academic gathering is requires proper planning. Unlike the other seminar/ symposiums where one present his or her own research and get interacted, in credit seminar you are reviewing others works and summarisng the presentation which will be evaluated. The onus of the work done by other scientist on a particular topic is on your shoulder to face first yourself and then the academic fraternity / collogues/ peers. Many times a good compilation of information serve knowledge enhancement of the audience and a compliment to the presenter. There are instances when students show their casual approach to credit seminar and without proper review and homework land to an awkward situation, may face repeat of the seminar. A good presentation of compiled information is equally pays; otherwise it will not attract the listeners. The current system of seminar delivery is well weighted on different aspects from composition of content, to language delivery, power point depictions; write of the summary of presentation etc. by an academic committee.

PG students expected to present their credit seminar after giving sufficient time to rehearse the talk and possible questions related to topic so that a suitable, logical and justifiable answer can be given. It also prepares the students to write up a good review paper on the topic after addition of few more content. Seminar though the part of academic programme but it also helps in personality development and an opportunity to show your scientific aptitude with your peers. This also addresses the anxiety and fear of stage if person is well prepared to deliver the content and studied the all peripherals of the topic.

There are many interesting topics which sometimes neglected due to their unfitness in our formula based seminar information compilation and summary writings. The topic generally to be chosen from the current aspects of your specialization so that it can help you in future to expand your current research. Current topics with global importance are best suited to catch the audience attention and informative for everyone but certainly with in depth review of the topic. Many times title of talk and content not matched or justified, which again a setback. While deciding the topic think twice of the major content it will going to deliver and what will be possible conclusion of the talk. Any seminar without any inference or conclusion is only wastage of time. Repetitive topics to be avoided from within university aswell as from other university. In era of digital world it is easily traced what topics and content delivered in other parts of India or globe. The uniqueness of topic, content and delivery is very important. Sometime a board thematic topic also not good as it will be difficult to summarise and present with in stipulated time frame.

Lastly the summary or gist script of seminar is an important part to glance your talk by audience, so avoid any kind mistakes even in reference writing. The font type and size also matters along with systematic thematic write up. In many universities at the end of seminar there is provision of submission of full size write up in 20-30 pages which again a treasure for the institute and student can publish a good review paper the seminar topic. There are various ways to improve the overall get up of credit seminar and one should take it a one time opportunity to encash the moment. The present compilation was thought for documentation of valuable topics dealt by the PG Forestry students and to bring transparency for restricting duplication of the seminar topics. I tried my best to compile the information but as there was no earlier document avialable in the college for seminar list/summary/ gist for pre 2013 seminars, I given gist details of the seminar conducted during my tenure of P.G. Coordinator from 2013-2014 to 2017-2018. I also tried to at compile the topics of seminar delivered pre 2013, which I was able to collect from 2002-2003 onwards from various sources. I thanks Dr. S.N. Sarvaiya, P.G. Seminar Coordinator (Horticulture) for providing the documents of pre 2012 seminars and all others who helped in this compilation. I am hopeful this compilation will be unique document for College of forestry and in future we will come such publication periodically 4-5 year intervals. It's a small step to travel a long journey of success for the college.

Dr. Manmohan J Dobriyal

Brief History of PG Seminars in College of Forestry (ACHF)

P.G. credit seminars are the part of course curriculum in all P.G. programmes but their impact is not just on indivual presenter's credit value. These also reflect the institute's academic portfolio. In ACHF, NAU the M.Sc. Forestry programme though started in 1992-93 but the current history of P.G. seminar was avaliable to trace it from 2002-2003 onwards which is listed below for a glance.

Academic Year (2002-03 to 2012-13)

S.N.	Student Name and Reg No.	Registered for the discipline	Name of Major guide and Co-guide	Topic of the PG Credit Seminar	Presentation date
2002-2003					
1.	Parekh Dhaval kumar J. 4-4833-2001	M.Sc. Forestry (Agroforestry)	Dr. N.S. Patil Dr. B.N. Kolambe	Recent research work done in Agroforestry	01/02 /2003
2.	Tandel Minal kumar B. 04-4834-2001	M.Sc. Forestry (Agroforestry)	Dr. M. U. Kukadia Dr. B.N. Kolambe	Production Technology of Teak	15/02 /2003
2003- 2004					
3	Limbasiya Rakesh kumar, T. 4-5255-2002	M.Sc. Forestry (Agroforestry)	Dr. D. B. Jadeja Dr. N.S. Patil	Importance of Joint Forest Management	03/01 /2004
4	Patel Dhanrajbhai R. 4-5255-2002	M.Sc. Forestry (Agroforestry)	Dr. M. U. Kukadia Dr. B.N. Kolambe	Role of Biofertiliser (microorganisms) on growth and development of Forestry tree species	03/01 /2004
2004-2005					
5	Patel Vimalkumar S. 4-5588-2003	M.Sc. Forestry (Agroforestry)	Dr. N.S. Patil Dr. B.N. Kolambe	Macro-propagation of Agroforestry tree species	29/01 /2005
6	Patel Rahul M. 4-5587-2003	M.Sc. Forestry (Agroforestry)	Dr. D. B. Jadeja Dr. B.N. Kolambe	Agroforestry of wasteland	05/02 /2005
2005-2006					
7	Kathota J. C. 4-0006-2004	M.Sc. Forestry (Agroforestry & Ecology)	Dr. B. G. Vashi Dr. B.N. Kolambe	*Gmelina arborea* Roxb; A alternative source of paper and pulp	12/07 /2005
8	Ahir Sanjaykumar M. 4-0001-2004	M.Sc. Forestry (Agroforestry & Ecology)	Dr. B. G. Vashi Dr. M. U. Kukadia	Macro-propagation as a tool for raising trees in mass	17/12 /2005
9	Dileswar Nayak 4-0004-2004	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. R. R. Shah	Role of trees in soil amelioration	30/12 /2005
10	Desai Mahesh kumar K. 4-0003-2004	M.Sc. Forestry (Agroforestry & Ecology)	Dr. B. G. Vashi Dr. D. B. Jadeja	Case studies of JFM in India	31/12 /2005
11	Prajapati Vijaykumar M 4-0009-2004	M.Sc. Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. B. G. Vashi	Growth response of forest tree species to biofertlisers	04/02 /2006

12	Patel Sandip M. 4-0008-2004	M.Sc. Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. B. G. Vashi	Production technology of *Dalbergia sisoo* Roxb.	18/02 /2006
13	Kumar Gautam 4-0007-2004	M.Sc. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. B. G. Vashi	Role of Multipurpose trees in Agroforestry	18/02 /2006
2006-2007					
14	Laxmikanta Behera 4-0146-2005	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. R.R.Shah	JFM peoples participation programme in India	16/09 /2006
15	Prajapati Ketan kumar N. 4-0147-2005	M.Sc. Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. B.N. Kolambe	Performance of intercrops in agroforestry systems	07/10 /2006
16	Ambuj Ranjan 4-0145-2005	M.Sc. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. S.R. Patel	Role of Nitrogen fixing tree species in agroforestry	16/12 /2006
2007-2008					
17	Pamar Mukeshbhai R. 04-245-2006	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. B.N. Kolambe	*Jatropha curcus* L. A promising Biodisel plant	15/12 /2007
18	Mehta Abhishek A. 4-0248-2006	M.Sc. Forestry (Agroforestry & Ecology)	Dr. B.G. Vashi Dr. D. B. Jadeja	Role of cryopreservation in forestry	15/12 2007
19	Abduladil A. Kazi 4-0247-2006	M.Sc. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. B.N. Kolambe	Application of Remote sensing in Forestry	15/12 /2007
20	Jayesh Pathak 4-0246-2006	M.Sc. Forestry (Agroforestry & Ecology)	R.R.Shah Dr. N.S. Patil	Role of forests in carbon sequestration	15/12 /2007
21	Tandel Minal kumar B. 4-0251-2006	Ph.D. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. D.B. Jadeja	Biotechnical intervention for tree improvement	15/12 /2007
2008-2009					
22	Tandel Minal kumar B. 4-0251-2006	Ph.D Forestry (Agroforestry & Ecology)	Dr. M.U. Kukadia Dr. D.B. Jadeja	Recent advances and future thrust of Agroforestry	15/12 /2008
23	Rajmani Kumar 4-0249-2006	M.Sc. Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. D.B. Jadeja	Status, importance and management of Mangrove forests	15/11 /2008
24	Shedage Swati Mahipati 04-0358-2007	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D.B. Jadeja Dr. M.U. kukadia	Role of agroforestry for sustaining soil fertility	15/11 /2008
25	Sofi Zahoor Ahmad 04-0359-2007	M.Sc. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. N.S. Patil	Potential impact of Short rotation forestry	15/11 /2008
26	Ahir Sanjaykumar M. 4-0348-2007	Ph.D Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. B.N. Kolambe	Soil amelioration through forest tree species	06/12 /2008
27	Parekh Dhavalkumar J. 04-0354-2007	Ph.D Forestry (Agroforestry & Ecology)	Dr. D.B. Jadeja Dr. B.N. Kolambe	Role of biofertliser in forest tree species	06/12 /2008
28	Makwana Hareshkumar Pitambarbhai 04-0351-2007	M.Sc. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. S.R. Patel	Role of Mycorrhizae in forestry	03/01 /2009

29	Rajveer Singh Chauhan 04-0357-2007	M.Sc. Forestry (Agroforestry & Ecology)	Dr. S.K. Jha Dr. R.R.Shah	Somatic embryogenesis in forest trees	03/01 /2009
30	Parekh Dhavalkumar J. 04-0354-2007	Ph.D Forestry (Agroforestry & Ecology)	Dr. D.B. Jadeja Dr. B.N. Kolambe	Influence of tree cover on physical properties of soil	30/05 /2009
31	Prajapati Vijaykumar M 04-356-2007	Ph.D Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. S.P. Saxena	Non pesticide (Non chemical) management of important insect pest of fertilizer	30/05 /2009
32	Ahir Sanjaykumar M. 4-0348-2007	Ph.D Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. B.N. Kolambe	Various seed treatment on germination and seedling growth in different forestry species	30/05 /2009
33	Dileswar Nayak 04-350-2007	Ph.D Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. D.B. Jadeja	Recent advances in Jatropha curcus L. research	30/05 /2009
2009-2010					
34	Dileswar Nayak 04-350-2007	Ph.D Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. D.B. Jadeja	Tree crop interaction in Agroforestry	01/08 /2009
35	Parmar Mukeshbhai R. 04-426-2008 *	Ph.D Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. M.U. Kukadia	Forests- its role in climate change	01/08 /2009
36	Vishnu Kanwar Solanki 04-0433-2008	M.Sc. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. S.R. Patel	Nutrient cycling in forest ecosystem	05/09 /2009
37	Sreedevi Madhusudanan 04-0432-2008	M.Sc. Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. D.B. Jadeja	Leaf litter dynamics of multipurpose trees.	19/09 /2009
38	Sangode Ekta Sharad 04-0430-2008	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. S.P. Saxena	Complementary, competitive and supplementary effect of trees under agroforestry	19/09 /2009
39	Sahailendra Bhalawe 4-0431-2008	M.Sc. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. S.R. Patel	Seed propagation and quality planting material in Teak	13/10 /2009
40	Patel Tejas Rameshbhai 04-0429-2008	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D.B. Jadeja Dr. S.P. Saxena	Gall insect a threat to Eucalyptus	05/12 /2009
41	Gaikwad Paresh Ganeshbhai 04-0428-2008	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. N.S. Patil	Biofuel and its importance	19/12 /2009
2010-2011					
42	Anil Kumar 2009	Ph.D Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr.K. G. Patel	Nutrient management in forest crops	18/09 /210
43	Rathwa Vikramsinh J. 04-0551-2009	M.Sc. Forestry (Agroforestry & Ecology)	Dr. S. K. Jha Dr. M.K. Mahatama	Status of teak research in India	18/09 /2010
44	Shriram Nagar 04-0554-2009	M.Sc. Forestry (Agroforestry & Ecology)	Dr. M. U. Kukadia Dr. M.B. Tandel	Role of Agroforestry in sustainable Agriculture	18/09 /2010
45	Mukesh Parihar 04-550-2009	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. M.K. Mahatma	Climate change and its impact on forests	04/12 /2010

46	Ankur P Patel* 2009	M.Sc. Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. D. B. Jadeja	Agrisilviculture: An opportunity for sustainable development	04/12 /2010
47	Chavda B K* 2009	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. N.S. Patil	Role of different growing media in forestry	04/12 /2010
48	Sanjeev Ranjan 04-0522-2009	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D. B. Jadeja Dr. M.K. Mahatma	Trade and marketing of Non timber forest products	01/01 /2011
2011-2012					
49	Ramraj Meena 04-897-2010	M.Sc. Forestry (Agroforestry)	Dr. D.B. Jadeja Dr. M.B. Tandel	Alley cropping- A tool for alternate landuse system	20/08 /2011
50	Rabari Baldevbhai Muljibhai 04-0895-2010	M.Sc. Forestry (Agroforestry)	Dr. D.B. Jadeja Dr. S.K. Jha	Status and prospective of short rotation forestry in India	16/09 /2011
51	Patel Navneet Kumar Maganlal 04-892-2010	M.Sc. Forestry (Agroforestry)	Dr. M.B. Tandel Dr. D.B. Jadeja	Managing the forests through community participation	16/09 /2011
52	Patel Satish Kumar S. 04-0894-2010	M.Sc. Forestry (Plantation Technology)	Dr. N.S. Patil Dr. M.B. Tandel	Advances in plantation Technology	01/10 /2011
53	Sushil Kumar 04-0903-2007	M.Sc. Forestry (Agroforestry)	Dr. N.S. Patil Dr. M.B. Tandel	Potentiality of deolied seed cakes as organic manure on tree seedling growth	01/10 /2011
54	Choudhary Dhavalkumar V. 04-0888-2010	M.Sc. Forestry (Agroforestry)	Dr. M.B. Tandel Dr. D.B. Jadeja	Bamboo: production technology & entrepreneurship	01/10 /2011
55	Sumit Kumar Gupta 04-0901-2010	M.Sc. Forestry (Forest Genetic Resources)	Dr.S.K. Jha Dr. Sanjay Jha	Salix: a potential species for phytoremediation of heavy metals in soil	14/10 /2011
56	Choudhary Sandipbhai S. 04-0889-2010	M.Sc. Forestry (Agroforestry)	Dr. M.B. Tandel Dr. D.B. Jadeja	Production technology of Teak (*Tectona grandis* Linn .f)	15/10 /2011
57	Suvera Anilkumar H. 04-0904-2010	M.Sc. Forestry (Agroforestry)	Dr. N.S. Thakur Dr. S.K. Jha	Non timber forest products from Agroforestry	15/10 /2011
58	Surendra Kumar 04-902-2010	M.Sc. Forestry (Watershed Management)	Dr. P.K. Shrivastava Er. N.M. Shah	Case studies on watershed management activities of Gujarat	18/11 /2011
59	Sachin Kumar Singh 04-0899-2010	M.Sc. Forestry (Agroforestry & Ecology)	Dr. D.B. Jadeja Dr. S.P. Saxena	Successful agroforestry systems in India	02/12 /2011
60	Raju Singh Rajpoot 04-0896-2010	M.Sc. Forestry (Forest Genetic Resources)	Dr. M.U. kukadia Dr. S.P. Saxena	Insect gall dynamics and their management in important forest tree species	16/12 /2011
61	Patel Ruchitkumar A. 04-0893-2010	M.Sc. Forestry (Agroforestry)	Dr. Bimal Desai Dr. D.B. Jadeja	Biodiversity: its value, use and management	23/12 /2011
62	Koyande Suyog Suresh 04-0891-2010	M.Sc. Forestry (Forest Genetic Resources)	Dr. S.K. Jha Dr. M.K. Mahatama	Current status of phytoremediation of cadmium through tree crop	23/12 /2011
63	Vikas Kumar 04-0905-2010	M.Sc. Forestry (Agroforestry)	Dr. Bimal Desai Dr. D.B. Jadeja	Reproductive biology of some tropical forest species	30/12 /2011
64	Bhagirath Singh Meena 04-887-2010	M.Sc. Forestry (Agroforestry)	Dr. D.B. Jadeja Dr. M.B. Tandel	Climate change and agroforestry	30/12 /2011

65	Shedage Swati Mahipati 04-0900-2010	Ph.D Forestry (Agroforestry)	Dr. N.S. Patil Dr. D. B. Jadeja	Glimpses of different carbon sequestration techniques with brief review of forest role	07/04 /2012
66	Vishnu Kanwar Solanki 04-906-2010	Ph.D Forestry (Agroforestry)	Dr.D.B.Jadeja Dr.M.B.Tandel	Potential agroforestry model for sustainable natural resource management and livelihood	07/04 /2012
67	Rakpan Jaswant* 2010	M.Sc. Forestry (Agroforestry & Ecology)	Dr. N.S. Patil Dr. M.U. kukadia	Propagation of bamboos	07/04 /2012
68	Nalage Nitin* 2010	M.Sc. Forestry (Agroforestry)	Dr. N.S. Patil Dr. M.U. kukadia	Use of plastic in Forestry	07/04 /2012
69	Desai Hardik Pravinchandra* 04-890-2010	M.Sc. Forestry (Forest Genetic Resources)	Dr. M.U. kukadia Dr. S.K.Jha	Tree improvement in Teak (*Tectona grandis* Linn. F.)	07/04 /2012
2012-2013					
70	Swati M.Shedage (04-0900-2010)	Ph.D. Forestry (Agroforestry)	Dr.N.S.Patil Dr.D.B.Jadeja	Tree-Crop interaction under agroforestry system	15/09 /2012
71	Vishnu Kanwar Solanki (04-906-2010)	Ph.D. Forestry (Agroforestry)	Dr. D.B.Jadeja Dr. M.B.Tandel	Cultivation of some medicinal Plant of India and its Export Potential	15/09 /2012
72	Panchal Jeegarkumar Sureshbhai 04-1052-2011	M.Sc. Forestry (Agroforestry)	Dr.N.S.Patil Dr.D.B.Jadeja	Role of Agroforestry in Biodiversity conservation	15/09 /2012
73	Durga Singh Nagar (04-1049-2011)	M.Sc. Forestry (Forest Biotechnology)	Dr.S.K. Jha Mr. R.S. Chauhan (Dr. M.J. Dobriyal)	Micropropagation of woody perennials of genus *Acacia*.	29/09 /2012
74	Mesariya Bhaveshkumar D. (04-1051-2011)	M.Sc. Forestry (Agroforestry)	Mr. Jayesh Pathak (Dr. M.B. Tandel) Dr. D.B. Jadeja	Macropropagation of Bamboo	29/09 /2012
75	Parmar Umeshkumar M. (04-1053-2011)	M.Sc. Forestry (Medicinal & Aromatic Plants)	Dr.B.S. Desai Dr.D.B.Jadeja	Alkaloids- the versatile groups of plant	29/09 /2012
76	Patel Hirenkumar S. (04-1054-2011)	M.Sc. Forestry (Medicinal & Aromatic Plants)	Dr.B.S. Desai Dr.D.B.Jadeja	Natural dyes: sources and importance	06/10 /2012
77	Surve Nilam Vijay (04-1058-2011)	M.Sc. Forestry (Watershed Management)	Dr.P.K. Srivastava Mr. Dileswar nayak	Watershed management using remote sensing and GIS	06/10 /2012
78	Prajapati Dharmeshbhai Hirabhai (04-1056-2011)	M.Sc. Forestry (Agroforestry)	Dr.N.S.Patil Dr.D.B.Jadeja	Macropropagation of *Acacias*	06/10 /2012

* Students left the degree programme

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P.G. CREDIT SEMINARS - COLLEGE OF FORESTRY

Academic Year 2013-14 to 2017-18

2014-2015					
14.	**Ahir Balavantkumar Ranbhai** 2030313001 Mob: 09687855928	M.Sc. Forestry (Agroforestry)	**Dr. Manmohan J Dobriyal** Dr. R. P Gunaga	Production of Quality planting material for agroforestry	**48**
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22.	**Kazi Abduladil Abdulhami** 02-1319- 2012 Mob:09426324841	Ph.D. Forestry (Agroforestry)	**Dr. D.B. Jadeja** Dr. M.B. Tandel	Birds, Agriculture and Forestry	**69**
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24.	**Kazi Abduladil Abdulhami** 02-1319- 2012 Mob:09426324841	Ph.D. Forestry (Agroforestry)	**Dr. D.B. Jadeja** Dr. M.B. Tandel	Agriculture, Tourism and Forestry	**75**
25.	**Manas Ranjan Nayak** 1030313002 Mob:08153993705	Ph.D. Forestry (Agroforestry)	**Dr. D.B. Jadeja** Dr. D.P. Patel	Reclamation of degraded lands through agroforestry interventions	**78**

26.	**Rajveer Singh Chauhan** 04-1320-2012 Mob:09714030160	Ph.D. Forestry (Agroforestry)	**Dr. D.B. Jadeja** Dr. S.K. Jha	Agroforestry for Biofuels	**81**
27.	**Jayesh Pathak** 04-1318- 2012 Mob:09662858490	Ph.D. Forestry (Agroforestry)	**Dr. D.B. Jadeja** Dr. M.B. Tandel	Fodder trees in Agroforestry - Importance and management	**84**
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75.	**Prajapati Dhavalkumar Rajeshbhai** 1030316001 Mob:08141454911	Ph.D. Forestry (Agroforestry)	**Dr. N.S.Thakur** Dr. R.P.Gunaga	Tree-C4/legume based agroforestry systems: Potential and prospects for fodder	**219**
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ACADEMIC YEAR : 2103-14

Seminar No.1

Speaker: **Mr. Harshal C. Bhasotiya**	Reg. No. 04-1311-2012
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. M.B.Tandel**	Venue: Room No. 101
Minor Adviser: **Dr. V. M. Prajapati**	Date: 05/10/2013

STATUS OF TREE COVER IN URBAN AREAS OF GUJARAT

Number of trees in the urban areas or non-forest areas (NFAs) of the state, as per Social Forestry Wing, has been more than that in the forested areas. The reason for this is success of social forestry and awareness among people that helped the departmental efforts. Tree cover in the non-forest areas was low in 1970s which subsequently increased to 251.0 million in 2004. This has further increased to 268.7 million in 2009 (Khanna, 2010). Gujarat is the pioneer state to implement social forestry in the country and a whooping number has been achieved with people's participation is self explanatory of this successful programme.

The state may have less forest cover and tree diversity, yet it has been successful in producing sufficient wood. In the state, it has been observed that districts like Anand, Mehsana, Gandhinagar and Kheda with meagre designated forest areas have been producing more timber as farmers have taken to farm forestry and are actively participating in tree plantation programmes. Over 160 tree species encountered during tree counting, about five dozen of them have been extensively planted in different parts of the state. These plantations are carried out, depending upon the suitability of the areas, especially soil and as per the demand of the wood and other forest produce.

Brief review of Survey work:

FSI (2011) estimated tree cover of the state using sample data of tree outside forest inventory collected over a period of six years, i.e 2004-10. The estimated tree cover in the state is 7,837 km^2 which is 4 % of the geographical area of the state. Seven districts of the state, namely Ahemdabad, Aanad, Bhavnagar, Dangs, Rajkot, Surendranagar and Vadodara have been inventoried this period.

Singh (2013) revealed that among various Municipal Corporations, Gandhinagar is the greenest city in the terms of tree density as well as the area under tree cover. Over all, Gandhinagar, Bhavnagar and Vadodara may be called as green cities having tree densities higher than the average density in the eight municipal corporations. Other municipal corporations Surat, Ahmedabad, Rajkot, Junagadh and Jamnagar have tree densities below the average.

He further stated that Gandhinagar Urban Development Authority has highest total number of trees (22,60, 100) and tree density per hectare (58.25) as compared to various Urban Development Authority while minimum total number of trees (1,66,410) and tree density per hectare (2.96) was recorded in Rajkot Urban Development Authority. Municipal Corporations has highest tree population (33,00,980), average tree density (24.76 trees/ha), tree cover (12,870 ha) and average tree cover of total area (9.65 %) as compared to Nagar Palikas.

Singh (2012) recorded highest tree cover (3,078 ha), tree and forest cover per habitant (147.6 m2) and trees per 100 persons (416.07) in Gandhinagar as compared to various municipal corporations whereas minimum tree cover (272 ha), tree and forest cover per habitant (2.7 m2) and trees per 100 persons (7.48) was reported in Junagadh and Surat, respectively.

In case of Nagar Palikas, the average tree cover percentage of geographical area is 5.4 %. Among various tree density classes highest number of Nagar Palikas fall under tree density below 10 trees per hectare. Out of eight Municipal Corporations, five Municipal Corporations failed short to reach at minimum standard of tree cover and it was maxim in Ahmedabad.

Khanna (2010) stated that Saurashtra and Kutch zone have highest tree population as compared to North and South zone of Gujarat.

According to the times of India (2013) tree count and tree density per hectare were increased in last decade in various zones and districts of Gujarat. Among various zones, Central zone reported highest number of trees (906.13 lakh) while tree density (31.41 trees /ha) was reported maximum in South zone. Among various

districts of Gujarat, Bharuch, Anand, Tapi, Gandhinagar and Mehsana have highest tree count and tree density whereas Surendranagar, Kutch, Jamnagar, Ahmedabad and Amreli have lowest tree count and tree density. Neem *(Azadirachta indica),* Gando Baval *iProsopis juliflora),* Desi Baval *(Acacia Nilotica),* Nilgiri *(Eucalyptus spp)* and Mango *(Mangifera indica)* are top five tree species over 400 tree species found in urban area.

Singh (2012) gave population of 20 major species in different municipal corporations. Out of 20 major species, Neem *(Azadirachta indica)* was most preferred species in different municipal corporations while Casurina *(Casurina equisetifolia)* was found to be less preferred species in different municipal corporations. Gandhinagar has also reported highest tree cover in percentage of geographical area in case of important cities of India.

Chaudhary *et al.* (2011) stated that forest and tree cover (297.00 km^2) was recorded maximum in Delhi while per capita green space was reported maximum in Gandhinagar (162.80 m^2/inhabitant).

Conclusion:

In last decade tree count and tree density per hectare were increased in various zones and districts of Gujarat. Among various Municipal Corporations Gandhinagar is the greenest city in the terms of tree density. Gandhinagar have also highest tree cover, tree and forest cover per habitant and trees per 100 persons. As far as tree count and tree density concerned Bharuch, Anand, Tapi, Gandhinagar and Mehsana were top five districts while Surendranagar, Kutch, Jamnagar, Ahmedabad and Amreli were bottom five districts. Out of 20 major species, Neem *(Azadirachta indica)* was most preferred species in different municipal corporations while Casurina *(Casurina equisetifolia)* was found to be less preferred species.

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Seminar No. 2

Speaker: **Mr. Jignesh B. Bhusara**	Reg. No. 04-1312-2012
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. N.S. Thakur**	Venue: Room No. 101
Minor Adviser: **Dr. S.K. Jha**	Date: 05/10/2013

IMPLICATIONS OF PUBLIC POLICIES AND FARMER'S PREFERENCES ON AGROFORESTRY IN INDIA

Agroforestry has a de facto "orphan" status in many national government settings. Agroforestry in principle is important to many ministries but in practice, it belongs to none. Agroforestry was first attached to the forestry sector but forest departments have historically had relatively few resources for programmes, been unfamiliar with agricultural practices, and often played a more policing than advisory role. The capacity for agroforestry to generate income is hardly ever recognized in policy documents. There are many governments that have put in place price floors for food products, subsidies for specific inputs like fertilizer, or favourable credit terms for certain agricultural activities. These almost always exclude agroforestry and therefore discourage its

practice (Leimona, 2011). The cumbersome procedures for getting permission for harvesting trees on private lands act as a further disincentive against tree planting by farmers (Kumar and Peter, 2002). Some of them impose restrictions on felling of some of the species on one hand and permitting some others to be felled and to sale (Guillerme *et aI.,* 2011). There are several policies on farming systems in India favouring tree planting on farm land to cater the industrial needs.

Presently there is general agreement about the magnitude and scale of the integration of trees into agricultural lands and their active management by farmers with several Govt. policies and policies of private sector. Zomer *et al.* (2009) conducted a global assessment of tree cover on agricultural land and found that 48 % of all agricultural land had at least 10% tree cover. Participatory forestry in various forms such as Social forestry, Community forestry, Farm/ Agroforestry, JFM etc. has evolved over the years by involving farmers and other land owners in tree plantations outside forests. Agroforestry has played an important role in providing valuable wood based raw materials to industry for meeting demand for various wood based products for society. The potential of agro/farm forestry has not been fully realized, as on one side farmers are encouraged to grow trees on their land, at the same time they face difficulties in harvesting their produce, in view of various restrictions on felling and transit of trees (GoI, 2012). However despite some difficulties Govt. and private public policies have encouraged the agroforestry. Still issues like Payment for environmental services are needed to be worked out.

Brief Review of Research Work:

Government policies in India

The adoption or lack of adoption of agroforestry is influenced by a variety of factors. Some have relatively little to do with policy - including climate conditions (e.g. rainfall), household and farm characteristics (e.g. resource endowment, size of household), and attributes of the particular agroforestry technology (e.g. time lag between costs and benefits) (Ajayi *et al., 2007).*

Independent India's first forest policy was in form of National forest policy 1952, in this policy the government mention the Tree land establishment for the amelioration of physical and climatic condition of country and aware the people for tree planting.

India in 1965, became the member of the International Poplar Commission and constituted the National Poplar Commission with the basic objective of cultivating poplars extensively to meet the requirements of timber for industrial as well as packaging cases and match box splinters. The match industry and plywood industry supported the fanner for plantation of the poplar and a good response was observed from farmers as well (Singh *et al., 2001).*

In the 1970s Govt. launched the farm forestry programme. Initially believed that the farmers will not adopt the tree on their farm land but farmer's response altogether was different. Original target of distribution of eight million seedling to farmer in U.P. in the period 1979-84, actual distribution had to be stepped up to 350 million to meet farmers demand (available at www.http://pianningcommission.nic.inL).

After that came the National forest policy 1988.The main aim of the policy is the environment stability and tree/forest cover increase to 33%. Policy emphasized that the forest based industries should raise tree plantations to meet their raw material requirement. This encourage the fanner to grow the tree on their farm land vis a vis industries came forward to establish the plantations on farmers' land with several schemes (buy back arrangement).

Madhya Pradesh Govt. launched the "Lok Vaniki Adhiniyam" in 2001. In this Act people harvest the some tree clad area. Act supported the fanner to grow the tree on the farm land (Raghavan and Srivastava, 2002).

Govt. of India introduced the Biofuel policy in 2009 (Available at www.http://pib.nic.inlnewsite/erelease.aspx?relid=56469), for development of the Biofuel in country. In this policy there are different scheme and subsidies to farmers for planting a Biofuel plants especially tree born oil seeds species (TBOs) (GoI, Planning Commission, 2003).

State Forest Policy and Strategic Plan (2008-2017), Punjab Forest Department, was declared in the year 2008.The aim of this plan is to increase the tree cover in the state from existing 6.3% to 15% by promoting social and agro-forestry activity in the state. (Government of Punjab, 2008).

In 2010, MoEF, GoI, launched the "National Mission for a Green India". Enhancing carbon sinks in sustainably managed forests and other ecosystems particularly on the non forest land. Various agroforestry models are proposed to increase the tree cover of country (GoI, 2010).

In an analysis of the tree farming scenario in Palakkad and Malappuram districts of Kerala, Kumar *et al.*, (1992) observed that the farmers somewhat averse to plant many indigenous timber trees and multipurpose trees owing to the lack of institutional support mechanisms, inadequate attention to land tenure questions, non-availability of quality planting stock, and policy constraints.

Guillerme *et al.,* (2010) studied the impact of different policies of Govt. and farmer's preference regarding agroforestry system in Kerala. They reported that adoption is generally determined by an interplay of farmer's preferences (mainly economic rationale) and public policies.

In Gujarat forest department launched the different agroforestry scheme for the development of agroforestry and tree cover of the state. Department distributed the quality seedlings to farmer and threw different extension activity. About 10 million clonal plants for agroforestry which are supplied to farmers at concessional rates in 2011 (GoG, 2010).

Chhattisgarh adopted an agroforestry policy in 2009 which goes as far as to include agroforestry products among several that it establishes a price floor and guaranteed market for, in order to ensure adequate production (Available at www.fao.org/ .../36094- 081bf412eb772690e5b90cc8d444880e3.pdf).

NGO/Private Based Policies in India

Due to directions of the National Forest policy, 1988, private industries started approaching the farmers with various incentive oriented schemes to attract the farmers (Initially large land holders) for tree plantations in the form of agroforestry and farm forestry.

The private sector seems to have played a more significant role in the awareness creation for agroforestry practices that produce relatively higher value product. This can be seen in the case of the rapid expansion of poplar growing by smallholders in India, where wood processors in Haryana and Punjab State were critical in awareness creation and eventually also in supplying seedlings (Zomer *et al., 2007).*

Paper and pulp, plywood and match splinters based industries like WIMCO, ITC, JK, Star paper mill, BILT etc. are directly involved in the promoting agroforestry systems integrating Eucalypts, Poplars, Casuarinas, Ailanthus etc, with buy back arrangements. These industries encouraged the farmers to adopt the farm forestry and agroforestry. Star Papers Mill, during 1995- 1996 distributed 1.0 million seedlings to the farmers for planting on their farm (Sharma *et al;* 2009).

In Gujarat SWDF (Sadguru Water and Development Foundation) working for water development. About 28 million seedlings have been planted, covering 28,167 acres of land (SWDF, 1996).

Most public policies in Kerala do not take into account the environmental services rendered by agroforestry or even by the farmers (Kumar, 2005; 2006). Similarly farmers dwelling in hills can be paid incentives for providing environmental services. The best known system to pay incentives is "Payments for Environmental Services" or PES, which make direct payments to farmers. So far, farmers dwelling in various states of Indian Himalayan Region have rarely been rewarded for their environmental services (Dhyani, 2011).

Conclusion:

It can be concluded that positive response of the farmers to policies on Agroforestry/Farm forestry may be attributed to: (i) policy with effective communication with farmers in order to enhance agroforestry practices by educating them about the primary to multifunctional values of agroforestry. (ii) Proper buy back. arrangement (iii) Incentives to farmers (vi) strengthening the markets for the agroforestry products (vii) flexibility and re-look in to the transit rules and (vii) policies which involved private sector. The policy issues like Payment for Environmental Services (PES) are needed to be addressed to benefit the farmers.

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Seminar No. 3

Speaker: **Mr. Jani Jigar. N.**	Reg. No. 04-1313-2012
Degree: M.Sc. Forestry (Forest Biotechnology)	Course No: FOR-591
Major Advisor: **Dr. S.K. Jha**	Venue: Room No. 101
Minor Advisor: **Dr. N.S. Thakur**	Date: 05/10/2013

STATUS OF MICROPROPAGATION OF ANTICANCEROUS MEDICINAL PLANTS

Cancer is generally described as an uncontrolled growth and spread of abnormal cells in the body. The division of normal cells is precisely controlled. New cells are only formed for growth or to replace dead ones. Cancerous cells divide repeatedly out of control even though they are not needed; they crowd out other normal cells and function abnormally. They can also destroy the correct functioning of major organs. Traditional medicines or herbal formulations can serve as the source of potential new drugs, so that initial research focuses on the active constituent of the plants. The development of novel plant derived natural products and their analogs for anticancer activity are going day by day. Plants have been an important source of medicine for thousands of years Tissue culture is useful for multiplying and conserving the species, which are difficult to regenerate by conventional methods and save them from extinction.

Review of research work

Catharanthus roseus

Singh et al., (2011) observed, for shoot regeneration MS basal supplemented with 1.5 mg/l BAP + 1.0 mg/l NAA was best. Mehta *et al.,* (2013) found 1.0 mg/l BAP to be most suitable for shoot multiplication from the nodal segments of C. *roseus.,* They also found when 0.5 mg/l BAP and 1.0 mg/l NAA applied simultaneously; it enhanced number of shoot bud, shoot length and per cent response of explants. Bakrudeen *et al.,* (2011) noted best shoot bud sprouting and maximum number of shoot and maximum response in MS media supplemented with 4.0 mg/l BA alone gives. Singh *et al.,* (2011) observed best rooting response with good quality of roots in half strength of MS medium supplemented with 2.5 mg/l IBA +0.5 mg/l NAA.

Taxus wallichiana

Hussain *et al.,* (2013) found best callus induction on MS media supplemented with 2 mg/l 2, 4-D + 5 mg/l AC. However, best caulogenic response was depicted by media supplemented with 2.0 mg/l BAP.

Camptotheca acuminata

Kang *et al.,* (2011) observed best shoot multiplication in media supplemented with 0.5 mg/l IBA. They also noted 0.5 mg/l IBA as the best rooting medium.

Heliotropium indicum

Kumar and Rao (2006) reported that MS media supplemented with 1.0 mg/l KIN + 0.5 mg/l IBA + 0.05 mg/l IAA gives highest number of shoots from apical bud explants. They also observed that the highest number of rooting can be obtained in half-strength MS medium supplemented with 0.1 mg/l IBA gave best results.

Gloriosa superha

Hassan and Roy (2005) found highest number of shoot in MS media supplemented with 1.5 mg/l BAP + 0.2 mg/l NAA. Half strength MS salts with 1.0 mg/l IBA+O.5 mg/l IAA gave best response for rooting.

Podophyllum hexandrum

Highest rate of multiple shoot formation observed by Chakraborty *et al.,* (2010) in MS media supplemented with 11.42 *milli micron* IAA.

Vicia faba

Hamdy and Hattery (2006) reported 2.0 mg/l BAP + 0.2 mg/l NAA as best growth regulator combination for shoot multiplication. Skrzypek *et al.,* (2012) noted best response for root formation in half strength of MS media supplemented with 2 mg/l NAA.

Curcuma longa

Panda *et al.,* (2007) observed medium containing 3.0 mg/l BA as optimum for shoot multiplication. Jala (2012) found highest average number of shoot, root, leaf, and plant height in MS media supplemented with 2.0 mg/l IBA.

Psoralia corylifolia

Jeyakumar and Jaybalan (2002) reported highest number of shoot regeneration in MS media containing 2.22 *microM* BAP. Tiwari and Pathak (2012) reported MS media supplemented with 10.0 mg/l BAP shows highest frequency of shoot. They also reported best response of rooting by 10.0 mg/l IBA. Jeyakumar and Jaybalan (2002) observed that maximum number of roots in the MS medium containing 4.92 *micro M* IBA.

Aegle marmelos

Warrier *et al.,* (2010) found that MS medium supplemented with 0.10 mg/l BAP + 0.10 mg/l KIN shows best result for shoot proliferation. Micro-shoots treated with lBA resulted good rooting response.

Tinospora cordifolia

Sultana and Handique (2013) reported that the maximum number of shoots can be produced on the medium containing 2.0 mg/l BAP + 4.0 mg/l KIN. Half strength MS medium supplemented with 2.0 mg/l IBA proved to be the best for rooting.

Bacopa monnieri

Kaur *et al.,* (2013) found that 1.0 mg/l BAP is best for shoot induction in *B. monnieri.*

Mehta *et al.,* (2013) reported that MS medium supplemented with 1.0 mg/l BAP evokes best response. They also observed that *O.S* mg/l BAP + 2.0 mg/l KIN gives best response for shoot multiplication. Kaur *et al.,* (2013) observed that the MS medium supplemented with 1.0 mg/l IBA is most efficient for development of healthy root system. For Better hardening, various author suggested different media for different species.

In ***Catharanthus roseus***, Soil: Sand: Peat moss (1:1:1) (Mehta *et al.,* 2013), FYM (1:1:1) *(*50% hardening, Singh *et al.,* 2011), Sand: Compost: Peat (1: 2: 1) (Haq *et al.,* 2013), in ***Gloriosa superba***, Vermi compost: Sand: Red soil (1: 2 : 2) (90% hardening, Arumugam and Gopinath 2012), in ***Bacopa monnieri***, Soil: Sand: Peat moss (1:1:1) (90% hardening, Mehta *et al.,* 2012), Garden soil: Sand (1: 1) *(*95% hardening, Tiwari and Singh 2010), soil: sand: manure (1:1:1) (100% hardening, Kaur *et al.,* 2013), in ***Heliotropium indicum***, Soil: Sand (1: 1) (Kumar and Rao 2007), in ***Curcuma longa***, Garden Sand: Soil (1: 1) (93% hardening, Goyal *et al.,* 2010), in ***Psoralia corylifolia***, Soil: Sand (1 : 1) (70% hardening, Sharon *et al.,* 2011), Garden soil: Vermiculite: Sand (1: 1: 1) *(*85% hardening, Jeyakumar and laybalan 2002), in ***Tinospora cordifolia***, Soil: Sand (2: 1) (80% hardening, Sultana and Handique 2013), Garden soil: Compost (1:1) *(*95% hardening, Bhat and Singh 2013), in ***Andographis paniculata***, Sand: Cocopeat: Compost (1: 1: 1) (86% hardening, Bidari *et aI.,* 2012), Sand: Soil (1: 1) (Martin 2003), has been reported.

Conclusion

Tissue culture protocols have been developed for several plants but there are many other species, which are over exploited in pharmaceutical industries and need conservation. Micropropagation will facilitate to conserve the threatened anticancerous plants due to overexploitation.

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Seminar No. 4

Speaker: **Mr. Mukesh Kumar**	Reg. No. 04-1314-2012
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. N.S. Thakur**	Venue: Room No. 101
Minor Adviser: **Dr. S.K. Jha**	Date: 19/10/2013

TREE CROP INTERACTION AND ECOLOGICAL BENEFITS OF TEAK BASED AGROFORESTRY SYSTEM

There are different agroforestry systems and practices prevailing throughout the world. These systems and practices have evolved due need of the rural people and some are market driven. The components of agroforestry systems are also influenced due to these factors. Similarly farmers preference regarding woody component either fruit or timber species is also affected by the nature and importance of the respective component. Teak is one of the oldest timber component agroforestry systems throughout the world. Teak is considered as king of timber species and suitable ideotype for agroforestry system because of having deciduous nature, sparse canopy and deep root system. Burma (now Myanmar) began planting teak using the taungya system in 1856. Natural cover of teak in the world is about 29.035 million ha and the planted teak in 38 tropical countries covers 4.346 million ha (Kollert and Cherubini, 2011). It is well established fact that vegetal components growing together on same piece of land have to share the available resources for their growth and development. Thus resulting in interaction what is called tree-crop interactions (TCI).

Brief review of Survey work:

Tree-crop interactions

Negative interaction: Agroforestry system namely Agri-silviculture (wheat + teak, Rice + teak), Silvi-medicinal (teak + aloe + coleus + stevia + kalmegh + lemongrass + citronella + palmarosa + patchouli), Agri-silvi-pastoral (groundnut + teak + grass + subabul), Agri-silviculture (teak + soybean + greengram + frenchbean + blackgram), Agri-silvi-hortipastoral (teak + papaya + sorghum + groundnut + chilli + ragi + grass + subabul), Agri-silvi-

pastoral (teak + subabul+ groundnut), Agri-horti-silviculture (paddy + maize + sunhemp + teak + *Eucalyptus tereticornis* + *Acacia molucana* + *Casuarina equisetifolia* + *Dalbergia sisoo* + sapota) and Agri-silvi-pastoral system (sorghum + groundnut + subabul + grass + teak) exhibited negative impact on under storey crops, whereas teak had beneficial effect with respect to its growth in studies carried out by Sharma *et al.* (2011), Nagarajaiah *et al.* (2012), Venkatarao *et at.* (2007), Mutanal and Nadagoudar (2004), Patil *et al.* (2010), Patil *et al.* (2011), Mutanal *et al.* (2002), and Mutanal *et al.* (2009) , respectively.

Positive interaction: Agroforestry system Agri-silvi-pastoral with tree crop combinations Sorghum + teak + grass + subabul Tgroundnut) developed by Mutanal & Nadagoudar (2004) showed positive tree-crop interactions.

Ecological benefits: Soil fertility, light transmission ratio, soil moisture status studied under Agri-silvi-pastoral system (sorghum + teak + grass + subabul + groundnut) by Mutanal & Nadagoudar (2004). Carbon stock and Carbon dioxide removal by teak under Agri-silvi-horti-pastoral system (Sapota + Grass + Teak + Field crop) was estimated to the tune of 0.03 83 kg/tree, 0.140 kg/tree, respectively (Patil *et al.*, 2010). In another study, Carbon stock and CO2 removal by teak (8 years old) under Agri-silviculture (teak + wheat) was estimated to the tune of 25.700 tons/ha and 94.319 tons/ha, respectively and soil fertility was increased under (Teak + wheat) system by Sharma *et al.* (2011).

Natural enemy of pest population (Biodiversity) was recorded higher in fringe area under Agri-silviculture system by Paul & Lalnunsangi (2011).

Conclusions:

The available studies on tree-crop interactions in teak based agroforestry systems revealed that in most of systems, under storey crops had low productivity exhibiting the negative impact. However, in all the studies it was teak productivity was increased. Although systems showed negative impact on understory crops nevertheless the loss in productivity may be accounted compensated by ecological benefits. Agroforestry systems with appropriate spatial arrangement and right orientation if practiced complementarily effect harnessed.

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Seminar No. 5

Speaker: **Mr. Sondarva Ramesh L**	Reg. No. 04-1317-2012
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. V.M. Prajapati**	Venue: Room No. 101
Minor Adviser: **Dr. M.B. Tandel**	Date: 19/10/2013

EFFECT OF DIFFERENT POTTING MEDIA ON SEEDLING VIGOUR OF IMPORTANT FOREST SPECIES IN NURSERY

Many different terms are coined for the artificial soil used in container nursery culture including potting soil, potting mix, soil mix, compost and growth medium. It is rarely appropriate to use the term 'soil' when referring to these materials, as soil is rarely a major component of growing media in a modem root trainer nursery. Because of the problems with field soil in containers, growers began supplementing soil with other materials to develop a mixture that would be suitable for container culture. Search of library records indicate that in the 1930s, John Innes HorticuItura Institute of England was the pioneer for developing a uniform, standardised growing medium. They had developed a loam based compost, that was subsequently amended with peat moss, sand and fertilizers (Bunt, 1988). By the early 1950s the first truly artificial growing media were created at the University of California which were composed of various proportions of fine sand and peat moss with supplemented fertilizers (Matkin and Chandler, 1957). The cornell peat-like mix, the predecessor of modern growing media, was developed at cornell University in the 1960s using various combinations of peat moss, vermiculite, and perlite (Mastalerz, 1977).

Brief review of research work:

Tiwari and Saxena (2003) revealed that the potting mixtures containing soil, sand and FYM in 1:2:2 and 1:2: 1 ratio recorded significantly higher collar diameter, leaf dry weight, shoot dry weight and root dry weight of seedling of *D. sissoo*.

Singh et al. (2000) studied the effect of soil media on germination, seedling length and nodulation of three NFT species. The equal proportion of sand, FYM and soil (1: 1: 1) increased germination percentage whereas shoot length and root length of seedlings increased by sand, FYM and soil (1: 1 :2) in *D. sissoo*. Mixture of sand, FYM and Soil in 1: 1: 2 ratio found better for shoot length and root length in *Acacia nilotica* and significantly highest number of nodule was observed in mixture of 2: 1: 1 in *Prosopis cineraria.*

Panwar (2009) stated that growing media containing Soil: FYM : Sand in 1:3:1 ratio significantly increased germination, germination energy, germination value, germination speed, plant height, collar diameter and number of leaves per plant in *Jatropha curcas.*

Majeed et at (20 I 0) recorded significantly maximum height, collar diameter, fresh shoot weight, fresh root weight and root length of *Albizia labbeck* in Soil: Sand: FYM ratio of 1 : 1 : 2.

Gunaga and Vasudeva (2011) reported that Soil : Sand: FYM (1: 1 : 1), Soil: Sand: vermicornpost (1 : 1 : 1) and Soil: Sand: Verrnicompost (1 : 1 : 2) were proved best with respect to seedling height, height from 1st branch, collar diameter and number in *Dysoxylum malabaricum*.

Ginwal et al. (2001) revealed that potting mixture having only compost 80 % recorded significantly higher height, collar diameter, shoot biomass and above ground biomass, while number of leaves and underground biomass were found maximum in *A. nilotica*. They also studied on different potting mixture (charcoal, rice husk and compost) and found that potting mixture having charcoal and compost (20%, 80%)

proved best potting mixture for shoot biomass, leaves biomass, above ground biomass, tap root biomass and under-ground biomass. Other morphological observation viz. seedling height, collar diameter, number of leaves, number of primary and lateral root were also found maximum in same treatment.

Annapurna et al. (2007) assessed the effect of various potting medium with eight different potting medium ingredient on seedling growth of *S. album* and found maximum height, collar diameter and shoot dry weight in potting media consisting sand and compost (25:75).

Patel et al. (2006) reported significantly higher shoot length, 'number of leaves per plant, fresh weight of shoot and dry weight of shoot of *Terminalia belleriea* seedling in potting mixture of Sand + FYM + Loamy soil (1: 2: 1).

Devar (2002) stated that potting mixture consisting of equal proportion of red soil, sand, FYM and ash (1: 1: 1: 1) reported significantly maximum growth of seedlings of *T. crenulata* as compared to other seven soil media.

Lavania et al, (2008) revealed that among various growing media, a media containing humus alone recorded significantly maximum collar diameter, shoot length, root length, seedling length, shoot weight, root dry weight, seedling dry weight and seedling vigour index for *Pinus wallichiana* followed by humus: soil medium.

Conclusion:

The different potting mixture definitely improves seedling attributes of different tree species. Among various potting mixtures combinations of Sand: FYM : Soil @ (1 : 2 : 1) and (1 : 1 : 2) ratios, Soil: Sand: Vermicornpost @ (1 : 1 : 1) and (1 : 1 : 2), Compost @ 80 %, Charcoal and Compost @ (20%, 80%) and humus alone significantly improves germination and seedling attributes of various tree species.

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Seminar No. 6

Speaker: **Mr. Gayakvad Paresh. G**	Reg. No. 04-1050-2011
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. D.B. Jadeja**	Venue: Room No. 101
Minor Adviser: **Dr. M.B. Tandel**	Date: 16/11/2013

IMPORTANCE OF AGROFORESTRY AS SUSTAINABLE LAND USE SYSTEM

Sustainability is the capacity to endure. It maintains long- term productivity without degradation of the natural resource base on which that production is dependant. Agroforestry is a sustainable land use system that maintains or increases total yields by combining food crops (annuals) with tree crops an or livestock on the same

unit of land, either alternately or at the same time, using management practices that suit the social and cultural characteristics of the local people and economic and ecological conditions of the area (Nair, 1989). Today world facing major conflict between food production and environmental degradation. Three critical problems confronting many developing countries in the tropics include: rapid population growth, declines in per capita food production; and environmental degradation. Thus, improved production systems that can build on the resilience of the traditional systems by utilizing external inputs or improved materials, and are able to produce surplus, need to be developed in order to relieve pressure on natural resources and ensure sustainable agricultural development.

The principal objective of agroforestry is to meet human needs by improving standards of living, alleviating drudgery and human suffering, and ensuring an improved quality of life for the majority of the rural population, without endangering the productive capacity of the resource base and polluting the environment (Eswaran and Virmani, 1993).

Brief Review f Research Work:

Pal *et al.* (2013) found that all chemical properties of soil were recorded maximum in forest land while minimum in agriculture and wasteland.

Parekh *et al.* (2005) found maximum number of pod per plant, yield per hectare when pulse crops were grown in open field condition and at par with *Mitragyna parvifolia* based agrisilvicultural system.

Grewal (1993) observed that different agrisilviculture system reduced soil loss, run off and nutrient loss as compared to cultivated fallow land. The negligible soil loss (0.07 tlha), run off (0.05 mm) and nitrogen loss (0.46 %) were recorded in agrisilviculture system of *Eucalyptus* + *Bhabar* grass which was followed by *Acacia catechu* + *Napier* grass (0.24 tlha and 2.00 mm, respectively).

Anonymous (2005) reported that agrisilviculture system of Shisham + Clusterbean recorded highest organic carbon (0.33%) whereas N, P, K was found maximum.in agrisilviculture system of Shisham + Greengram.

Prasadini and Sreemannrayana (2007) stated that *Acaccia nilotica* +Stylo grass recorded highest total N, P percent and EC of soil whereas Agri-Silvi-Horticulture system improved pH and organic carbon of the soil.

Singh (2006) revealed that adoption of silvipastoral system decreased soil pH and EC and increased organic carbon, available N, P, K after 6 years of planting. In case of different tree species *Prosopis juliflora* decreased pH and increased organic carbon after 20 years.

Bhatia and Singh (1991) reported highest fodder yield in *Acaccia catechu +Eulaiopsis binata* (71.3+5.3) as compared to *Dalbergia sissoo* + *Chrysopogon fulvus* (64.0 + 5.5).

Patel *et al.* (1992) revealed that Napier grass + Millet hybrid gave highest green forage and dry matter yield than other combinations of agroforestry systems.

Gill *et al.* (2004) observed that the fresh rhizome yield of turmeric decreased significantly as the age of poplar increased.

Prajapati (2006) reported highest BCR (2.34) of turmeric under Kalam as compared to Arjun (1.73), Casuarina (2.05) and control (1.48). Similarly, Ahir (2006) registered highest BCR (4.05) in Arjun as compared to Kalam (2.57), Haldu (1.63) and control (1.41).

Rajmani (2009) reported highest yield of maize var. Ganga safed-2 which was followed by Narmada moti and Sweet com madhuri under Agri-silvi-horticulture system. Mertia (1992) reported that shelterbelts of *Cassia siamea* showed effective control of soil loss as compared to bare soil.

Solanki (2003) studied the alley cropping system using managed Leucaena rows with fodder crops and reported that Leucaena with fodder crops recorded higher total biomass as compared to the fodder alone.

Bhatia and Singh (1991) reported highest leaf yield dry weight and nitrogen in *Leucaena leucocephala* (5000-8000 Kg/ha and 180-250 Kg/ha, respectively) while nitrogen content percent in *Tephrosia candids (3.8%)*

Haider *et at.* (2005) concluded that higher soil loss was recorded in alley cropping width of 4.5m whereas intra-row spacing of 0.5m recorded lesser amount of soil loss.

Conclusion:

The role of agroforestry in sustainable agriculture provides fodder and fuel without compromising with food grain production, decreases soil and nutrient loss. It improves the physicochemical properties of soil. Shelterbelts improve nutrient and moisture contents in soil and also decreases wind velocity to protect the soil. Proper combinations of agriculture crops, fruit crops, fuel and fodder trees, increases the production potential and

sustained the soil fertility, also implemented on problematic soils. During poor rainfall years, it covers the risk in production of required products.

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Seminar No. 7

Speaker: **Mr. Shailendra Bhalawe**	Reg. No. 04-1057-2011
Degree: Ph.D. Forestry (Agroforestry)	Course : FOR 692
Major Advisor: **Dr. D.B.Jadeja**	Venue : Room No. 101
Minor advisor : **Dr. M.B.Tandel**	Date: 16/11/2013

EFFECT OF VARIOUS AGROFORESTRY SYSTEMS ON SOIL STATUS

Agroforestry systems are considered more sustainable and favourable to improve the soil properties. Presence of trees in combination with annual crops is believed to offer systematic plant cover to protect the soil from erosion as well as enhancement of moisture status of soil. Nair (1984) reported that agro-forestry, agri-horticultural and agri-pastoral systems have the potential to reduce erosion and runoff and to maintain soil organic matter, improve soil physical properties and augment nitrogen fixation and promote efficient nutrient cycling. *In situ* retention of rainfall on the land itself by agronomic measures in the rhizosphere for better plant growth is one of the essential factors which can be achieved through agroforestry practices and by suitable agronomic measures. The productivity in agroforestry system is higher as compared to sole cropping systems,

because higher yield of crop has been observed in forest influenced soil than in ordinary soil. Agroforestry systems based on traditional knowledge with water management as an integral component are more effective for rehabilitation of degraded community lands than afforestation with plantation crops (Maikhuri *et al.* 1997).

Brief review of research work

Anonymous (2005) reported significantly higher organic carbon percentage (0.31 %)) in combination of Neem + cowpea AF system which was followed by combination of Neem + cluster bean and Neem + green gram. They also observed maximum available nitrogen (197.3 kg ha-^{1}) in combination of Neem + cowpea AF system which was at par with Neem + green gram (191.3 kg ha-^{1}) and Neem + clusterbean (189.0 kgha-^{1}).

In case of Shisham based AF system, they further observed that the combination of Shisham + green gram AF system recorded significantly highest organic carbon percentage (0.33%) and least in cluster bean sole cropping (0.19%). After harvesting available elements nitrogen (190.3 kg ha-^{1}), phosphorus (35.80 kg ha-^{1}) and potassium(203.7 kg ha-^{1}) were found higher in combination of Shisham + green gram AF system which was at par with Shisham + til for nitrogen (183.7 kg ha-^{1}) and phosphorus (34.50 kg ha-^{1}) respectively.

Anonymous (2000) stated that the AF system of subabul + maize recorded significantly higher organic carbon percentage (0.72%) and available elements nitrogen(283.5 kg/ha), phosphorus (25.5 kg/ha) and potassium (320.5 kg/ha) as compared to sole cropping of subabul and shisham plantation whereas moisture status percentage on two different level (0-15cm and 15-30 cm) showed maximum in subabul + maize as compared to shisham sole planting.

Sharma (2010) evaluated different land use systems and found that agroforestry system proved superior in terms of maintaining higher chemical soil quality index as compared to other land use systems. Arable land, which is continuously under agriculture had the lowest soil quality index. They also observed that overall physio-chemical properties, exchangeable nutrients and chemical soil quality index were reported maximum in agroforestry systems and lowest in arable land.

Susan *et al*. (2011) analysed soil and found that mean sand fractions ranged from 9 – 48 %, silt fractions from 21 – 64 % and clay fractions from 6 – 71 %, with no significant differences between land cover groups.

Mutanal and Nadagoudar (2004) revealed that the all over benefits from agroforestry systems and nutrient status were increased in agroforestry systems as compared to sole cropping of sorghum under red soil. They also reported that the values of soil pH and EC were decreased (from 6.13 to 5.97 and 0.13 dsm-^{1} to 0.38 dsm-^{1}, respectively) with inclusion of teak with grass/sorghum/subabul seedling as compare to sole cropping of sorghum.

They further stated that the benefits percentage and nutrient status were increased in Gn+T+Sb and Gn + T based agroforestry systems as compared to sole cropping of Groundnut under red soil whereas values of soil pH and EC were decreased in teak with grass/groundnut/subabul seedling as compared to sole cropping of sorghum.

Saha *et al. (*2007) stated that the *Pinus kesiya* based agri-silviculture systems noted maximum organic carbon, soil aggregation, infiltration through extensive root system and improved soil conservation through constant surface cover with leaf biomass as compared to natural fallow.

Majumdar *et al.* (2004) revealed that all the agroforestry systems significantly increased organic carbon as compared to initial status. The maximum contribution was done by silvi-horti-pastoral AFs. The same system also registered 43.20 % higher exchangeable Al as compared to natural forest and consequently a maximum decrease of 0.50 units in pH. The exchangeable Ca, Mg, Na, K and Al content were higher in all the systems as compared to natural forest. They further stated that all agroforestry systems showed maximum improvement in soil chemical properties as compared to agriculture sole crops.

Majumdar *et al*. (2002) revealed that organic carbon content was increased in all the AFs (agroforestry system) including natural fallow and it was found maximum in Jhum land (3.42%) as compared to natural fallow (2.61%). They also observed maximum exchangeable of Ca, Mg, Al and available N, P, K and S cations under agri-horti-silvipastoral and Jhum land AFs which was followed by natural fallow and silvi-pastoral systems.

Vittal *et al.* (2006) stated that different agroforestry systems definitely improved chemical properties of soil as compared to uncultivated fallow and agriculture systems.

Pal *et al.* (2013) found that all chemical properties of soil were recorded maximum in forest land while minimum in agriculture and wasteland.

Panwar *et al. (*2013) concluded that chemical properties of soil was recorded maximum in *Terminalia arjuna* based agrisilviculture system and lowest in *Bixa oreliana* based agrisilviculture system.

Panchal (2013) stated that Eucalyptus and spider lily based agroforestry systems showed significantly higher soil chemical nutrient which was followed by Mango+Teak+Brinjal based agri-silvihorticulture system.

Conclusion:

Various agroforestry systems like- silviagriculture, Agri-horti-pastoral, silvihortipastoral systems contributed significantly in enhancing the physical and chemical properties of soil especially the top soil through effective recycling of nutrients. The overall improvement in the physical properties of soil is suggestive of role of agroforestry systems for sustainable land use.

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Seminar No. 8

Speaker: **Mr. Shashi Bhushan Sharan Pandey**	Reg. No. 04-1316-2012
Degree: Ph.D. Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. D.B. Jadeja**	Venue: Room No. 101
Minor Adviser: **Dr. M.B.Tandel**	Date: 30/11/2013

STRATEGIES FOR MANAGEMENT OF TREES OUTSIDE THE FOREST AND PLANTATION- A TOOL FOR PROMOTION OF THE VEGETATION COVER

Trees have been part of local land use systems for millennia.With increasing population and growing consumerism, there has been severe pressure on food production and employment generation, particularly in agro-based developing countries like India (Hegde, 2010).The trees outside forests (TOF) play a significant role in livelihood of rural and urban people of the country both economically and ecologically. TOF exist in the form

of small woodlots and block plantations, trees along linear features such as roads, canals, bunds etc. and scattered trees on farmlands, homesteads, community lands and urban areas (Kumar and Lakhchaura, 2008). Tree grower co-operatives should be enhanced in every state as per NTGCF for the rehabilitation and management of degraded village common lands (Balooni and Ballabh, 2000). India's achievement in increasing the area under forest plantations has been impressive. The current rate of tree plantation is about 1.5 m ha. per annum where as deforestation is taking place @ 1.0 m ha. per annum, hence, 5.0 m ha. /annum plantation area is to be increased to achieve the target object of 33% area under forest/tree cover.

Brief Literature Review:

FAO (2010) reported maximum forest area in Russian Federation (809 m. ha.) among top ten countries in the world while India ranks 10th with 68 m. ha. only.

In a report of APFSOS II (2009) the area of major land use categorized during 1950-2003. The net sown area was found maximum in 1990-91 (143 m. ha), net irrigated area was noted maximum in 1999-2000 (56.76 m.ha) and forest area was registered maximum in 2001-02 (69.49 m. ha).

Kumar and Lakhchaura (2008) conducted a study on growing stock in TOF for top 10 species and found that *Mangifera indica* has maximum volume percentage (11.18) and highest total stem percentage (8.9).

According to the report of FSI (2001), maximum area of tree cover was noted in Andhra Pradesh (9,011 Sq. Km.) i.e. 3.28% of geographical area which was followed by Maharashtra (8,269 Sq.Km.) i.e. 2.69 % but the maximum percentage tree cover of geographical area (5.54 %) was found in Dadra Nagar and Havali which was followed by Tamilnadu (4.65%).

But on the basis of latest report of FSI (2011), Maharashtra state has maximum area of tree cover (9,079 Sq. Km.) i.e. 2.95 % of geographical area which was followed by Rajasthan (8,272 Sq.Km.) i. e. 2.42 % of geographical area but the maximum percentage of geographical area under tree cover was found in Lakshadweep (14.23 %) which was followed by Chandigarh (8.93%) and Delhi (8.07%).

FSI (2011) estimated growing stock composition in TOF for top ten species and found that maximum total volume (10.05 %) in *Mangifera indica* whereas percentage of total stem (6.38 %) was noted in C*ocos nucifera*.

Among various states /UT, annual potential production (TOF) of timber was noted maximum in Uttar Pradesh (5.082 million cubic meter) which was followed by Maharashtra (3.519) and Rajasthan (3.463). Whereas, annual availability of fuel wood was reported maximum in Uttar Pradesh (2.253 million tonnes) which was followed by Gujarat (2.137) and Rajasthan (1.541). The growing stock (TOF) was found maximum in Jammu & Kashmir (147.745 million cubic meter) which was followed by Maharashtra (147.029) and Gujarat (117.993) (FSI, 2011).

The total tree cover in Gujarat state is 4% of its geographical area whereas forest cover is 7.46% as per FSI, 2011 report.

About 6.55 million trees grow in 167 urban areas (municipal corporations & municipalities) of Gujarat as evident from total tree enumeration, first time done in 2011 in all urban areas of Gujarat with average tree density of 18.9 trees/ha. The canopy cover (53.9%) and tree density (152 trees/ha.) was found maximum in Gandhinagar, the capital city of Gujarat, are the highest in India; thus Gandhinagar may be listed amongest the greenest cities in the world (Singh, 2013).

Chaudhary *et al.* (2011) stated that forest and tree cover (297.00 km^2) was recorded maximum in Delhi while per capita green space was reported maximum in Gandhinagar (162.80 m^2/inhabitant).

FAO (2010) reported that annual increase in planted forests was noted maximum in China (1932 thousand hectares per annum) whereas India ranks IVth having 251 thousand ha/yr among top ten country of the world during1990-2010.

The total cumulative area of forest plantations (in '000 ha) was found 31,209.17 by all agencies from 1951-1999 in India. It was found maximum in UP (4,185.77) which was followed by MP (3,364.13), Gujarat (2,981.08) and Maharashtra (2,965.07) (FSI, 1999).

FSI (2011) estimated the species wise plantations by various state forest departments, the maximum area (in '000 ha.) was 1360.91 of *Eucalyptus species*, i.e.08.87 % of total species whereas *Tectona grandis* was second one, having1330.09 (8.67%) in the country.

Why plantations?

Plantations are most successful method to ascertain regeneration in long rotation species, provide recreational, aesthetic and ecotourism opportunities, satisfies diverse basic needs of rural population through agroforestry as providing fruits, fodder in lean periods, fuel wood and ensures use of cattle dung as manure, which ultimately restore fertility and productivity of agricultural lands, conservation of wide variety of germplasm from different seed sources, (Luna, 1995). No doubt, much labour extensive, thus offers a great scope for employment.

Management strategies for plantations & tree outside the forests:

Identification of land/area, tree species & use must be done on priority basis for any TOF or plantation work. Unlike crop calendars, forestry operation calendars must be made as per species & locality, end use (Khosla, 1993). Expansion of city or urbanization or establishment of new building society should be permitted after approval of tree plantation plan in adequate area, say about 15% of the area. (Singh, 2012). Attempts should be made to do original data collection as first time done in Gujarat (2011) i.e. total tree enumeration in all urban areas. Some incentives should be provided by the government in the form of income tax relaxation with respect to plantation area annually. (Solutions, 2001)

Conclusion:

It can be concluded that tree outside the forests and plantations has expanded rapidly in all aspects. There is an urgent need to review and reform the existing policies and laws relating to growth and felling of trees with consistent efforts for establishment of forest plantations and tree outside the forest on private lands in perpetuity. Not only the mentioned strategies are sufficient for increasing the tree outside the forest/plantations but also their protection, regular care and monitoring is necessary for fruitful results.

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Seminar No. 9

Speaker: **Mr. Laxmikant Behera**	Reg. No. 04-1059-2011
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-691
Major Advisor: **Dr. D.B. Jadeja**	Venue: Room No. 101
Minor Advisor: **Dr. S.K. Jha**	Date: 30/11/2013

FOREST CARBON SEQUESTRATION: IMPORTANCE, METHODOLOGY AND CASE STUDIES

Forest plays a vital role in mitigating the diverse effects of environmental degradation and increasing concentration of CO2 in the atmosphere. It also mitigates the climate change. Forests promote sequestration of carbon (C) into soil and biomass. One of the major issues of global C concern today is the rapidly increasing level of CO2 (@ 2ppm yr^{-1}) in the atmosphere and its potential to change the world climate. Elevated levels of CO2 and other green house gases in the atmosphere have increased global average surface temperature by 0.6±0.2°C (IPCC, 1999). The rising CO2 levels have severe implications on the functioning of physical and biological systems of the world. In order to mitigate this problem IPCC, (1996) advocated an increase in the size of the carbon pool through massive afforestation and reforestation, besides maintaining the existing C pools in the terrestrial ecosystem (natural forest).

Brief review of research work:

I-Natural forest:

Gupta (2009) reported Shorea robusta as a main species contributed 2224358.4 Metric Tonnes and 189235.2 Metric Tonnes as the total carbon in Sal stratum and miscellaneous stratum, respectively.

Bhora et al. (2011) revealed that mean carbon sequestration rates were higher in non- degraded sites (5.86 t/ ha /yr) of Oak and Pine forest as compared to degraded sites (1.41 t/ ha/yr) of Oak and Pine forests.

Chatterjee et al. (2009) found that in Ponderosa Pine, total aboveground carbon pool of the unmanaged stand was 121 Mg C. ha-l which was significantly higher than, intensively harvested (50.1 Mg C /ha), even aged (44.5 Mg C. /ha) and uneven-aged (29.1 Mg C./ ha) stands. Similarly in Lodgepole Pine, aboveground C pool of unmanaged stand was 3.7 times greater than the even-aged stand. Again the total ecosystem C pools in even-aged, uneven-aged and intensively harvested stands of Ponderosa Pine were lower than the unmanaged stand by 34%, 32% and 20% respectively where as for Lodgepole Pine, the even-aged stand was 53 % lower C content than the unmanaged stand.

Tang et al. (2012) stated that mean ecosystem C stock in tropical limestone forest was 214 t C /ha with the tree layer being the largest carbon pool of 155 t C / ha, comprising 73 % of the total ecosystem C stock of the forest. Roots contributed 20 % of the C stored in the tree layer and estimated soil organic carbon (SOC) at 40 cm represented 72-84 % of the SOC to 1 meter.

Bois et al. (2009) revealed that total ecosystem C stocks in regenerating and juvenile stands were approximately 40% lower than that in mature and old growth levels. It means, the total ecosystem C stocks was found maximum in old stand (268 t C / ha) which was at par with mature stand (248 t C /ha) over juvenile stand (164 t C /ha) and regenerating stand (148 t C/ ha).

Kranabetter (2009) stated that the largest component of the forest biomass was procured from stem biomass (wood plus bark) at 73 % followed by roots (18 %), branches (5 %) and foliage (4 %). Similarly, the C content of live tree was maximum in site with very rich nutrient regime (VR- Devil's club; 457 Mg C ha^{-1}) and lowest in site with poor nutrient status (P-Cladonia; 95 t C ha^{-1}).

Fox et al. (2009) found that maximum C stock in total aboveground biomass (AGB) of lower montane primary forest (167.9 Mg.C/ha) as compared to lowland secondary forest (90.2 Mg.C/ha). It was In the trend of lower montane primary forest that sequesters more C than the lowland secondary forest.

Borah and Chandra (2010) studied the C content in three different Bamboo species and found that *Bambusa balcooa* stored maximum total above ground C (234.17t ha').

2. Planted Forest

Yadava (2010) found that maximum C sequestration occurred in the agroforestry system S_1 (18.53 t Cha^{-l}; *Populus deltoides* + wheat) and minimum in system S3 (4.66 t Cha-l; P. Deltoids+ wheat boundary rlantation). Annual C sequestration was maximum in S_3 (2.06 t C / ha/ yr) and minimum in system S_3 (0.52 t C /ha/yr)

Dhruw et al. (2009) concluded that C sequestration in leguminous and non-leguminous tree species was found to be in the range of 434.63 to 867.96 kg ha/yr. Leguminous trees like *Cassia siamia* and *Dalbergia sissoo* were able to sequester more carbon than the non-leguminous tree like *Tectona grandis.*

Ulman and Avudainayagam (2012) when compared the total biomass C content of *Ailanthus excelsa* by formula method and assumption method, It found that 9.29 t C ha^{-l} (1st year) to 54.24 t Cha^{-l} (3rd year) by formula method and 12.27 t Cha^{-l} (1^{st}year) to 63.41 t C / ha (3rd year) by assumption method. Total C content increased with increase in age.

Devakumar et al. (2012) found that a maximum C stock in cardamom plantation was 162.33 tha-I and it was minimum in areca nut plantation 127.30 t /ha.

Chauhan et al. (2009) explained that highest tree stem C storage (6.05 t/ ha) and total C storage(11.26 t/ ha) were recorded in *Acrocarpus fraxinifolius* plantation and these were the lowest in *Syzygium cumini* tree (0.73 t /ha and 2.16 t /ha respectively).

Devaranavadgi et al. (2012) found that among 6 plant species under investigation, above ground C sequestration was found highest in *Azadirachta indica* over different age groups (9.22 t ha^{-l}, 21.82 t /ha, 28.76 t /ha land 29.03 t/ ha respectively during 4^{th}, 5^{th}, 6th &7^{th} years) followed by *Simarouba glauca.*

Karu et al. (2009) studied C stock in three different layers viz. tree layer, shrub layer and herb layer. However, tree layer recorded maximum C in all the three stands over shrub and herb layers and it increases at a rate of32 % and 67 % with age of 21 years and 36 years.

Rabari (2012) compared the C stock among clonal and seedling based plantation of Eucalyptus hybrid. It was found that clonal plantation contributed maximum C (22.19 kg/tree) as compared to seedling based plantation (20.20 kg/tree) at 4 years of age.

Madhusudanan (2010) observed that among 4 species studied, the aboveground C sequestration potential was found maximum in Albizia procera (189.93 Mg/ha) and minimum in *Gmelina arborea* (19.25 Mg/ha) after 20 years of age.

Patel (2012) found that higher above ground C sequestration was recorded in *Terminalia arjuna* (904.83 kg/tree) followed by *Mangifera indica* (860.82 kg/tree) and minimum in *Manilkara achras* (148.42 kg/tree).

Gupta and Sharma (2012) assessed SOC under various land use system. Among all, SOC was more under *Cedrus deodara* (91.42 t ha'). Out of total SOC pool of all land use systems, *Cedrus deodara* contributed maximum share of (16.04%) and minimum by *Mangifera indica* (8.13%).

Conclusion:

Forests, both natural and plantation, played vital role in fixing the atmospheric CO2 and help in reducing the effects of climate change. There are several methodologies adopted while estimation of C stock in natural and artificial forests. Forest inventory for C stock determination methodology (as per IPCC,GPG) is widely adopted in natural forest condition whereas destructive and non-destructive methods are adopted in planted forests. In natural forest condition, primary forest and unmanaged forest sequester more C as compared to other types of forest. Stems of trees are the major contributor of C storage than roots and foliages. Herbs, shrubs, lianae also contribute C storage in less quantity among forest ecosystem. Review showed that fast growing species like Albizia pro cera, Populus deltoides, Ailanthus excelsa, Azadirachta indica and leguminous species like Cassia siamia and Dalbergia sissoo sequester more C within short time and rate of C sequestration increases with increase in age of the plantation. Also clonal plantations are more efficient in C sequestration as compared to seed originated plantations.

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Seminar No. 10

Speaker: **Mr. A.A.Mehta**	Reg. No. 04-1060-2011
Degree: Ph.D. Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. D.B. Jadeja**	Venue: Room No. 101
Minor Adviser: **Dr. M.B.Tandel**	Date: 30/11/2013

CULTIVATION AND PRODUCTION OF SAFED MUSLI

Chlorophytum borivilianum Santapau & Fernandes (Liliaceae) also known as 'Safed Musli' is a traditional rare Indian medicinal herb which has many therapeutic applications in Ayurvedic, Unani, Homeopathic and Allopathic systems of medicine. Its root contains steroidal and triterpenoidal saponins, sapogenins and fructans which act as therapeutic agents and play vital role in many therapeutic applications. It is a rich source of over 25 alkaloids, vitamins, proteins, carbohydrates, steroids, saponins, potassium, calcium, magnesium, phenol, resins, mucilage, and polysaccharides and also contains high quantity of simple sugars, mainly sucrose, glucose, fructose, galactose, mannose and xylose. (Thakur, 2009) *C. borivilianum* is distributed mainly in Southern Rajasthan, Northern Gujarat and Western Madhya Pradesh in India. Amongst all thirteen species of *Chlorophytum* genus, *C. borivilianum* produces the highest yield and highest saponin content.

Brief review of research work:

Relation between yield and yield component:

Kumar *et al.*(2010 a) stated that among the four upper ground traits only two *i.e.* canopy spread and leaf length showed significant positive correlation with root yield while all the under- ground traits showed significant and positive correlation.

Planting:

Yaseen *et al.* (2013) found that planting on 15 July give maximum tuber per plants (except year 2006-07), root length, fresh weight and dry root yield in a two year study trial. In case of spacing, safed musli planted at 15 cm x 15 cm spacing gave maximum dry root yield. In the same study, they found that among all planting

methods, planting on ridge gave maximum dry root yield (492 kg/ha) which was at par with planting on raised bed (431kg/ha).

Pandey *et al.* (2007) reported that 2 feet raised bed planting method was found superior to other methods and gave significantly higher number of fingers per plant(10.10), finger length (8.88 cm) and fresh root yield (4.90 quintal per ha) while root diameter (0.63 cm) was found non-significant. There was a sharp increase in the all above parameters up to 90 days after planting.

Yaseen *et al.* (2013) studied the effect of size of planting material on growth and yield of safed musli and revealed that all the parameters viz. sprouting percentage, number of leaves per plant, number of tubers per plant, average root length, fresh root yield and dry root yield was significantly higher in the planting material having 3 to 4 tubers. They also found that maximum percentage of sprouting (96.4), mortality (13.4) as well as dry root yield (709) was significantly higher in plant density of 25 plants per square meter. While number of tubers per plant (15.7) and average root length (13.0 cm) was significantly higher in the 20 plants per square meter and 15 plants per square meter plant density respectively. Whereas number of leaves per plant (16.0) and fresh root yield (19.5) were significantly higher in 11 plants per square meter plant density.

Nutrients:

Ganokar *et al.* (2006) found that uptake of nitrogen, phosphorus and potash was significantly higher in the 20 t per ha FYM level and 75 kg per ha nitrogen level. They also found that all the yield contributing parameters and root yield parameters were significantly higher in above mentioned FYM and Nitrogen level.

Somnath (2008) revealed that maximum number of roots per plant, length of roots, dry and fleshy root yield were found at 50:50:50 NPK ratios. Nitrogen, phosphorus and potash uptake was also noted maximum at this NPK level. He also noticed that combination of black polythene mulching and 40 t per ha FYM gave maximum fleshy and dry yield of safed musli.

Solanki *et al.* (2011) stated that a combined application of 30-30-40 kg ha^{-1} NPK with *Azotobacter chroococcum* and *Glomus fasciculatum* significantly increased tuber diameter, tuber length, number of tuber per bunch, fresh root yield and dry root yield.

Dave and Tarafdar (2011) noticed that application of mycorrhizal fungi *Glomus intraradices* significantly increased root biomass in 270 days old plant.

Saponin content:

Somnath (2008) revealed that total saponin content was significantly higher in the treatments like 50:50:50 NPK kg per ha dose, mulching with black polythene and 40 t per ha FYM dose.

Dave and Tarafdar (2011) found that saponin concentration in tuber of safed musli at harvesting time was significantly higher in crop inoculated with AM fungi *Glomus mosseae.*

Mishra *et al.* (2008) found maximum saponin content in safed musli after 8 month of storage in glass container among all other storage containers.

Intercropping:

Singh *et al.* (2011) observed that when safed musli was intercropped with Beans gave significantly higher dry root yield of safed musli than sole safed musli crop. They also found significantly higher total LER under intercropping with beans.

Kumar *et al.* (2010) noticed that growth attributes like plant height, plant spread, functional leaves, leaf size and leaf area was higher in intercropping of safed musli with tamarind plantation.

PAR:

Kumar *et al.* (2010) found that Intercepted PAR at 60 DAP was maximum in safed musli sole crop (32134) in comparison with safed musli planted with tamarind plantation (28556).

Yaseen (2013) observed that significantly higher fresh root yield and dry root yield was found in 75% PAR.

Economics:

Kumar *et al.* (2010) found yield performance and B:C ratio was maximum in safed musli as intercrop in tamarind plantation.

Patel *et al.* (2009) noticed net profit and C:B ratio was higher in safed musli sole crop than other intercropping system.

Singh *et al.* (2011) noticed maximum gross and net return in the intercropping of bottle gourd full population with safed musli.

Production of active constituent:

Bathoju and Giri (2012a) reported highest percentage of explants response in 3 mg/l IBA and they also noticed increase in stigmasterol and hecogenin after 25 days of root culture. In another study Bathoju and Giri (2012 b) also noticed higher callus induction in safed musli leaf sheath explants with 1.5 mg/l 2,4 –D and they found highest stigmasterol and hecogenin in regenerated plants than other stages of differentiation of callus.

Birader *et al.*(2011) found that by using stem disk explants, best treatment for shoot initiation was1 mg/l BAP while 1mg/l IBA was best for root initiation. They found hardening with net house condition was best for acclimatization. Dave *et al.* (2003) noticed micro-propagation of safed musli by using young shoot bud in MS media with sucrose and Phytagel^{TM} was best for shoot initiation. They also found that hardening with Soilrite^{TM}, MS salts and vitamins was good for acclimatization.

Mishra *et al.* (2009) studied harvesting pattern of fruit, tubers of selected medicinal plants in the natural forests of Nagpur district. They noticed that safed musli is harvested by uprooting whole plant with small pick axe in month of September where as maturity time is November and they also noticed adulteration of *Chlorophytum borivilianum* with other Chlorophytum species.

Conclusion:

From Forests, Safed musli (*Chlorophutum borivilianum*) is generally harvested by uprooting whole plant and there is problem of adulteration of other species. So cultivation of pure safed musli is needed to reduce the pressure on wild population. Planting of 3 to 4 tubers of Safed musli on ridge or raised bed at 15 cm x 15 cm spacing and density of 25 plants per square meter give higher yield. According to the local condition, Application of NPK 30:30:40 to 75:65:50 kg ha^{-1}, FYM 20 to 40 t ha^{-1} and application of biofertilizer like Azotobacter and Mycorrhizal fungi can increase the yield and saponin content. Storage of safed musli in glass container will be helpful for maintaining saponin content. Intercropping of safed musli with other crops can be done according to the locality. Production of active constituents like stigmasterol and hecogenin can be achieved through in-vitro culture. Tissue culture techniques can be used for mass production.

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Seminar No. 11

Speaker: **Mr. Shashi Bhushan Sharan Pandey**	Reg. No. 04-11316-2012
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. D.B. Jadeja**	Venue: Room No. 101
Minor Adviser: **Dr. M.B. Tandel**	Date: 17/05/2014

FEASIBILITY OF GINGER & TURMERIC CULTIVATION UNDER DIFFERENT AGROFORESTRY SYSTEMS

Agroforestry denotes a sustainable land and crop management system that strives to increase yields on a continuing basis, by combining the production of woody forestry crops (including fruit and other tree crops) with arable or field crops andlor animals simultaneously or equentially on the same unit of land, and applying management practices that are compatible with the cultural practices of the local population. (ICRAF) Intercropping is the practice of growing annuals or relatively short duration crops in the formative years of orchards in the interspaces of perennials (Chundhawat and Gautam, 1993). Vegetable crops are high output crops as compared to other field crops. They can be cultivated in plains and hills at different altitudes. Growing of vegetables in agroforestry systems not only cater house hold requirements of farmers, but also provides employment for labour round the year (Bandyopadhyay, 1997). India is the largest producer of Ginger and Turmeric in the world. Ginger and Turmeric are most suitable vegetables (Spice crops) for intercropping in agroforestry systems in Prehumid -Subhumid and Semihumid-Semiarid regions from lowlands (500 m) to medium elevation (500-1000 m) (Nair, 1993).

Brief Literature Review

Anonymous (2006) reported maximum ginger production (517.8 th.tons) in India whereas the productivity (47.5 t/ha) was highest in USA among world.

Anonymous (2012) reported maximum ginger area and production in Kamataka among Indian states since 2009-2012[except max. production (predicted) for Orissa in 2011-12].

Anonymous (2006) reported maximum ginger area and production in Assam among Indian states whereas maximum productivity is of Gujarat.

Angles *et at.* (2011) reported actual and projected exports of Indian turmeric to major importing countries and found the chief importer for Indian turmeric is UAE followed by Iran.

Anonymous (2006) reported maximum turmeric area and production in Andhra Pradesh among Indian states where as maximum productivity is of Gujarat.

Anonymous (2012) reported maximum turmeric area and production in Andhra Pradesh among Indian states since 2009-2012.

Prajapati (2006) reported highest BCR (2.34) of turmeric when it was grown under kalam as compared to Arjun (1.73), Casuarina (2.05) and control (l.41).

Gill *e/ at.* (2004) observed that the fresh rhizome yield of turmeric decreased significantly as the age of poplar increased.

Vanlalhluna and Sahoo (2009) examined the performance of three tree species *viz., Alnus nepalensis. Melia azadirechta* and *Gmelina arborea* and their interactive effects on ginger and turmeric crop yield during establishment period. Maximum height, collar diameter and yield of ginger and turmeric were found under treecrop association than pure crops after a 3-year period.

Prapajati *et al.* (2007) studied the growth and productivity of Ginger (*Zingiber officinale)* under Kapok *(Ceiba pentandra)* based agrisilviculture system. The result revealed that the intercropping of ginger under *C. pentandra* gave higher yield and income under un-pruned condition and with FYM @ 30 t/ha as compared 25% pruned and lowest as a sole crop.

Das *et at.* (2011) conducted an intercropping trial on 6-year-old aonla *(Emblica officinalis* Gaertn.; CV. A-7) orchard planted at 6 m x 6 m spacing The intercrops grown were turmeric, ginger and arbi. The results indicated that the production of fruits significantly increased due to intercrops and it was maximum in aonla in

association with turmeric (13.30 t/ha) followed by arbi (11.71 t/ha). Economic analysis of the systems in terms of benefits: cost ratio revealed that 'aonla + turmeric' gave a higher value (6.29) which was followed by 'aonla + ginger' (3.45) and 'aonla + arbi' (3.20).

Chaturvedi *et al.* (2009) observed that the farmers in different state take different crop sequence along with poplars either as boundary (2.5 - 3.5 m) or blocks (spacing 4x5 m or 4.5x4.5 m) but ginger /turmeric found everywhere.

In intercropping trial with Khasi mandarin orchard on sloppy land, five arable crops (groundnut, rice, ginger, turmeric and soybean) were tested and it was revealed that mandarin + ginger land use system gave the highest net returns followed by mandarin + turmeric. No adverse effect on the growth of mandarin trees was observed (Tewari, 1995).

Tejwani (1994) studied different vegetables with Poplars and found that the net income was highest with turmeric followed by ginger.

Bari and Rahim (2010) conducted an experiment to evaluate the growth and productivity of ginger under sissoo based Multistrata Agroforestry System (MAF) during the period of April 2005 to December 2006. The rhizome yield was reduced at closer spacing of *Dalbergia sissoo* as compared to that of wider spacing. The highest yield (25.76 t/ha in 2005 and 25.47 tlha in 2006) was recorded under wider spacing of sissoo+guava based MAF during both the years. The lowest yield (12.64 t/ha in 2005 and 11.15 t/ha in 2006) was recorded in narrower spacing of sisoo+lemon based MAF in both season, which was followed by the narrower spacing of, sissoo+guava based MAF and sole cropping of ginger. The yield under wider spacing of sissoo+guava based MAF increased by 39.24 per cent in 2005 and 52.15 per cent in 2006 over sole cropping of ginger.

Ahmed *et al.* (2007) conducted an experiment to investigate the performance of ginger and turmeric grown under different agroforestry system. The result revealed that fresh rhizome and best yield were observed in guava+coconut based agroforestry system for both ginger(32.43 t/ha) and turmeric (38.78 t/ha) but highest morphological growth was observed in lemon + coconut based agroforestry system.

Conclusion:

There is immense potential in agroforestry systems to enhance productivity and sustainability of agricultural lands or the land resources which have never been put into service due to so many factors, can be better used by adopting different agroforestry practices like inclusion of ginger and turmeric cultivation in following systems like Agrisilvi, Agrihorticulture, Agrihortisilvi, Homegardens and bamboo based agroforestry systems for high remuneration and useful combination (age and spacing of tree species) if properly managed (with recommended agronomic and/or silvicultural practices for particular region) could increase the production potential sufficiently. Hence, such systems need to be made popular among farmers for sustainable livelihood.

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Seminar No. 12

Speaker: **Mr. Laxmikant Behera**	Reg. No. 04-1059-2011
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. D.B. Jadeja**	Venue: Room No. 101
Minor Adviser: **Dr. S.K. Jha**	Date: 23/05/2014

AGROFORESTRY: A TOOL FOR LIVELIHOOD AND ENVIRONMENTAL BENEFITS

Agroforestry is a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (ICRAF, 2006). Land-use options that increase livelihood security and reduce vulnerability to climate and environmental change are necessary in the present context. Traditional resource management adaptations such as agro-forestry systems may potentially provide options for improvement in livelihoods through simultaneous production of food, fodder and firewood as well as mitigation of the impact of climate change. Agro-forestry has many potential, such as enhance the overall (biomass) productivity, soil fertility improvement, soil conservation, nutrient cycling, microclimate improvement, carbon sequestration and biodiversity conservation etc. Nowadays agro-forestry has gained popularity among 'farmers, .researchers, policy makers and others for its ability to contribute significantly in meeting deficit of tree products; socio-economic and environmental benefits.

Brief review of research work:

l-Agroforestry for Livelihood

Sharma *et al.* (2008) revealed that the cultivation of mustard with kinnow (Rs.56408) is more profitable than wheat with kinnow (Rs.53070) and the net profits in both the cases were higher as compared to the sole kinnow (Rs.47170).

Roy and Tewari (2012) found that average carrying capacity of the improved silivipastoral practice was 4.1 sheep/ha/year against 3.6 for sole *Cencrus ciliaris* pasture and 1.3 for sole *Hardwickia binata* plantation. They also revealed fuelwood and leaf fodder production potential of *Prosopis cineraria- Acacia nilotica* system was maximum and minimum in *Zizyphus spp-P.cineraria-Salvadora spp.* System.

Rathore *et al.* (2011) found that maximum fodder biomass in hedge species *Crotalaria macrophyl/a* and fodder crop maize of 395 q/ ha as compared to other.

Thaware *et al.* (2004) stated that the net returns amongst the two tree species were more when rice was grown with *Acacia auriculiformis* than with *Casuarina equisetifolia.* The maximum net return was obtained in the treatment planting *A. auriculiformis* at 5mx 2m spacing (Rs. 28,233/ha/year) as compared to net returns from C. *equisetifolia* with rice and rice alone.

Jama *et al.* (2008) concluded that the average of fuelwood yield for three fallow durations was highest in *Tephrosia candida* (12.5 t/ha) and the lowest in *Tephrosia vogelii* (7.3 t/ha). .

Ilorkar *et al.* (2011) explained that teak based dry land agrisilvicultural system intercropped with soybean, black gram produces timber and pole when planted at a spacing 8m x 2m total of Rs. 169577 return/ha.

Verma and Thakur (2010) revealed that Peach+ Setria + *Withania somnifera* gave maximum net returns of Rs. 50116/ha which was followed by Peach+ Morus+ Setaria+ *W. sornnifera* giving Rs. 48093/ ha at nitrogen

dose of 120 kg/ha. Similarly for M+S+ *W. somnifera* treatment gave higher B:C ratio of 3.87 followed by Grewia +Setaria + *W. somnifera* of 3.57.

Tripathi (2012) found that the fruit yield of peach increased when aromatic and medicinal plants namely Tulsi, Ashwagandha and Kalmegh were grown between the rows of high density (4.5 m x 2 m spacing) of 5 year old peach plantation and also there was significant increase in biomass of all these medicinal plants.

Dhyani *et al.* (1996) revealed that sericulture based agroforestry system produced highest cocoon returns from TR-4 mulberry variety ofRs. 33449 and least in local variety.

Viswanath *et al.* (2010) reported that among the three models, sandal block plantation at 4m x 4m spacing appears to be most financially viable with an NPV of Rs. 12.5 lakhs, B:C ratio of 3.3, IRR of 33 % , EAI of Rs. 2.14 lakhs and LEV of 1.42 lakhs at 15% discount rate.

Regeena *et al.* (2007) stated that Model III (Crop+ Poultry+ Floriculture+ Ornamental fish+ Vermicompost unit) produced maximum net returns of Rs. 215442/ha with B:C ratio of 2.07 as compared to other models of home garden.

Venkatesh *et al.* (2010) revealed that net profit as a whole, the bigger unit size (201-400) of Japanese quail registered 42.5 % more than the unit size of 50- 100 and 33.4% more than the unit size of 101-200.

Pandey *et al.* (2002) concluded that the maximum output/input ratio was found in the fish pond component of 9.82 as compared to other components of homegarden.

Kabir and Webb (2009) found that maximum household income was obtained from homegarden (71 US$) in Khulna region whereas maximum percent share of home garden towards household income was in Khulna and Satkhira region (7 %).

Bhatt and Bujarbaruah (2005) reported that the total output/ input ratio (labor component included) was highest (1.76) in cropfish- dairy-MPTs-fruit trees-hedge rows-vermiculture-liquid manure-broom grass as compared to others.

Krishnamurthy and Krishnamurthy (2011) revealed that citrus monocropping has the lowest benefit/cost (B:C) ratio, which indicates that multicropping is more economically viable. The economic profitability increases by up to 62.6% in the citrus-banana system and 92.9% in the citrus-vanilla system, comparatively with the citrus monocrop system.

Rahangdale *et al.* (2014) found that bamboo based agrisilviculture system gave higher net monetary return (Rs 21029/ha) as compared to sole crops (Rs 9801/ ha). However, the magnitude was high when crops were grown with *Dendrocalamus strictus* (Rs 22708/ha) as compared to *Bambusa arundinacea* (Rs 19350/ha).

Bari and Rahim (2012) concluded that the highest benefit-cost ratio of 3.54 was recorded from coconut+guava based MAF which was followed by coconut+lemon based MAF.

Chauhan *et al.* (2013) advised that the income from mongo+ garlic/onion (spice crops) + fruit crops + poplar based system had maximum income (US$ 5725), which was much higher than traditional rice-wheat rotation.

Solanki (2013) found that herbal medicinal crops namely basil, kalmegh and mint when grown under Sapota- Jatopha recorded higher benefit:cost ratio (1 :3.01, 1:2.86 and 1:2.31, respectively) as compared to their sole crops (1 :2.28, 1:2.02 and 1:1.60, respectively).

Rai *et al.* (2000) concluded that the percentage of adoption of agroforestry increases (72% to 100 %) with increase in holding size from small to large. The overall net income from trees of agrofc restry of the adopted households is 6.8 %, which is comparatively higher than the non-adopted households (1.7%). Overall per household; per year' economic-benefit adopted agroforestry from the trees ofagroforestry is Rs. 8337/ha as compared to Rs. 2638/ha non-adopted agroforestry.

Dwivedi *et al* (2007) reported that out of the total sample farmers, majority (71.3%) have indicated that agroforestry is a source of additional income. The other determinants of agroforestry as pointed out by farmers are emergency source for cash (17.5%), supplemental employment (4.4%), other reasons like soil conservation (4.4%) and fuel wood (2.5%).

2-Afgrofrestry for Environmental Benefits . " .

Prasad *et al.* (2010) found that among the tree species *Albzia procera* appears to be the most efficient in capturing carbon and removing CO_2 from the atmosphere while *Anogeissus pendula* the least.

Yadava (2010) found that maximum carbon sequestration occurred in the agroforestry system S_1(18.53 t C/ha); *Populus deltoides* + wheat) and minimum in system S_3 (4.66 tC/ha); *P. deltoids*+ wheat boundary plantation). Annual C sequestration was maximum in S_1 (2.06 t C/ha/yr) and minimum in system S_3 (0.52 t C/ha/yr).

Chauhan *et al. (2009)* explained that highest tree stem C storage (6.05 t/ ha) and total C storage (11.26 t/ha) were recorded in *Acrocarpus fraxinifolius,* plantation and these were the lowest in *Syzygium cumini* tree (0.73 t/ha and 2.16 t/ha, respectively).

Panwar and Chakravarty (2010) reported that proportion of vegetables were more in villages and least in homegardens of urban areas whereas timber trees were the choice of people of rural areas and ornamental and medicinal plant proportionately preferred in urban areas.

Varadaranganatha and Madiwalar (2009) in Uttara Kannada district of Karnataka observed that mean number of species per hectare was maximum in home garden than the other agroforestry systems.

Saikia *et al.* (2012) reported that tree density was highest in the small homegarden (4574 individuals/ ha) and frequency of species occurrence increased with decreasing homegarden size and found maximum on medium-sized homegarden (236 spp.) species rich.

Srinivasan *et al* (2010) explained that the maximum water holding capacity (M WHC) was significantly higher in Ailanthus interplanted plots when compared to casuarina and leucaena and control plot (coconut alone). Moreover coconut interplanted with ailanthus at 30-45 cm soil depth showed highest value of MWHC and sole coconut plot at 15-30 cm soil depth registered the lowest.

Qaisar *et al.* (2007) stated that available nutrients (N, P, K) and soil microbial count was highest in populus + fodder based system as compared to other systems.

Tandel (2003) reported that major nutrients like N (103.84 kg/ ha), P_2O_5 (9.54) were found maximum under sissoo and K_2O (113.7 kg/ ha) under bamboo where as micronutrients like Fe (345 mg/ 100 g), Mn (55 mg/ 100g), Cu (16 mg/ 100 g) under casuarina and Zn (20.29 mg/ 100g) under sissoo trees found maximum. .

Conclusion:

Agroforestry is a sustainable land use systems provide the livelihood security as well as environmental benefits. Review showed that agroforestry enhance the livelihood options by producing food, fodder, fuelwood, timber, other produce (medicine, silk), income, employment etc. Further, it provide the environmental benefits like mitigation of climate change through carbon sequestration, biodiversity conservation and soil enrichment through soil physico-chemical properties and fertility improvement. Thus the adoption of the agroforestry system by society on the basis of their need for livelihood enhancement for subsistence and encashment of environmental benefits for broader global concern.

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Seminar No. 13

Speaker: **Mr. A.A.Mehta**	Reg. No. 04-1060-2011
Degree: Ph.D. Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. D.B. Jadeja**	Venue: Room No. 101
Minor Adviser: **Dr. M.B.Tandel**	Date: 23/05/2014

TREE CROP INTERACTION: SPECIAL REFERENCE TO ALLELOPATHY

An ecological interaction refers to the major impact of one species on the other or on the same type of species. In general there are three types of interactions: neutral, positive and negative. Among these neutral interactions are very rare and happen only when the niches are wide apart. Specifically, the interactions in agroforestry systems can be complementary (positive), supplementary (neutral) or competitive (negative). Further, these can be below ground or above ground. In agroforestry, particularly simultaneous systems, trees (being perennial, large sized and dominant) have a major and continuous influence on the crops and determine the extent of interactions. Allelopathy plays a key role in both Natural and managed ecosystem. In agro-ecosystems, several weeds, crops, agroforestry trees and fruits trees have been shown to exert an allelopathic influence on crops, thus, affecting their germination and growth adversely (Kohli *et al.* 1998). Allelopathy can affect many aspects of plant ecology including occurrence, growth and plant succession, the structure of plant communities, dominance, diversity and plant productivity. The term allelopathy was derived from the Greek words *allelo-* and *-pathy* (meaning "mutual harm" or "suffering"). It is any direct or indirect harmful effect that one plant has on another or mutually on each other through the production of chemical compounds that escape into the environment.

Brief review of research work:

Krishna *et al.*(2003) studied the allelopathic effect of different Agroforestry tree species on different vegetable crops. They found that shoot length and root length of brinjal were significantly reduced with leaf leachates of *Casuarina*. In case of chilli, *Casuarina*, Bamboo, Teak and Acacia significantly reduced the root

length. Whereas in tomato reduction in shoot length was significant and maximum with leaf leachates of Bamboo.

Marwat and Khan (2006) reported significantly minimum germination of wheat by 150g/l leaf extract of *Acacia nilotica* whereas in wild oat it was by 100g/l and 50g/l leaf extract of *Eucalyptus camaldulensis*. Minimum plant height was noticed in wheat and wild oat by leaf extracts of 100g/l *Acacia nilotica* and 150 g/l *Eucalyptus camaldulensis*.

Sahar *et al* .(2005) reported that among all samples of leaf extract of *Acacia nilotica* and *Eucalyptus rostrata* maximum allelopathic effect on all parameters of *Zea mays* and *Phaseolus vulgaris* were by *Eucalyptus rostrata* 10% leaf extract. They also noticed that as concentration of leaf extract of both tree species was increased, total chlorophylls and total soluble sugars were decreased whereas amount of Abscisic acid was increased.

Hiwale *et al.* (2007) revealed that out of the nine crops taken in test, germination was significantly inhibited in three crops *viz*., okra, moth bean and sesame. Whereas shoot and root dry weight were promoted in soybean, maize, green gram, and sesame. There was reduction in dry matter in green gram, pigeon pea, fodder jowar, whereas maximum reduction was reported in neem leaf leachate in okra, sun hemp and moth bean.

Siddiqui *et al.* (2009) noticed that 50g/500ml aqueous extract of *Prosopis juliflora* reduced seed germination and radicle lengh in *Triticum aestivum* var-Lok-1.

Alagesaboopathi and Deivanai (2011) found maximum allelopathic effect of 25% aqueous extract of *Sesbenia grandiflora* leaves on germination and seedling growth of *Cajanus cajan* var. Vamban 2.

Sasikumar *et al*. (2001) identified phenolic compounds in four different Eucalyptus species and studied their role on germination and growth of red gram. Syringic acid as well as mixture of all phenolic compound show allelopathic effects.

Zhang and Fu (2010) found that when concentration of aqueous litter extracts of Eucalyptus species was increased there was apparent reduction in the radicle and pumule length of two test crops i.e. Radish and Chinese cabbage whereas in cucumber 2% of leaf extract of eucalyptus species reduced root length. Different concentration of eucalyptus root exudates also gave inhibitory effect on the growth of the test crops.

Kaur *et al*. (2011) observed different volatile oil from leaves of *Eucalyptus tereticornis* and also found that when the concentration of important oil content like α -pinene, 1,8-cineole and oil of *Eucalyptus tereticornis* was increased, there was reduction of germination and all growth parameters.

Djanaguiraman *et al.* (2005) noticed reduction in germination, shoot length, dry matter, vigour index, chlorophyll a, chlorophyll b, total chlorophyll and Soluble protein in black gram, rice and sorghum at 20% leaf leachate of *Eucalyptus globulus*.

Singh *et al.* (2001) registered minimum germination of test crops in field of *Populus deltoieds* having parent soil as compared to control and field of *P.deltoieds* having replaced soil. They also noticed that after experiment phenolic content in the soil was increased which is responsible for allelopathic effect.

Manimegalai *et al.* (2012) noticed maximum inhibitory effect in 100% concentration of *Tectona grandis* leaves on germination of both black gram and green gram.

Lalmuanpuii and Sahoo (2011) reported that 100% leaf extract of *Tectona grandis* significantly reduced seed germination, shoot and root extension, fresh and dry weight of shoot and root of *Oryza sativa and* Zea mays.

Jadhav and Gaynar (1995) found minimum germination, pumule length, radicle length and dry matter in rice and cowpea in case of *Casuarina equisetifolia* leaf leachates soaked for 24 h period.

Shalpa *et al.* (2011) revealed that inhibition of germination and growth parameters of mungbean and soybean varied according to different parts of plants and soil from different place. The sequence of maximum allelopathic effect in *Melia azedarach* is T2 (root zone soil) >T3 (soil mulched dry leaf) >T4 (soil watered with aqueous leaf extract) >T1 (top soil) > T5(control / fresh garden soil)

Rokiek *et al.* (2010) found that 25 % mango leaf extract caused strong, harmful effects on *Cyperus rotandus* which was not found in lower concentration. They also found significant inhibition in response to different concentration of the extract. The degree of inhibition was concentration dependent. The allelopathic effect of the leaf extract was highly detectable at concentration of 25%. Extract of 25% caused accumulation of total phenol content which increased to a very high extent after 30 and 75 DAS in both foliage and underground organs.

Ashafa *et al.* (2012) revealed that germination of *Cassia occidentalis* was totally nil in 15% and 20% dry leaf extract of mango whereas 20% fresh leaf extract gave minimum germination. There is also reduction of lengh of radicle and pumule of *Cassia occidentalis* with increase in concentration of leaf extract and totally nil in 15% and 20% dry leaf extract.

Conclusion:

In agro-ecosystems agroforestry trees and fruits trees have been shown to exert an allelopathic influence on crops, thus, affecting their germination and growth adversely. Some tree species like *Azadirachta indica*, *Casuarina equisetifolia*, Bamboo spp., *Acacia nilotica*, *Eucalyptus* spp., *Tectona grandis*, *Mangifera indica*, *Populus deltoieds Melia azedarach* etc. have shown allelopathic effect on different crops by affecting its physiological and growth parameter like germination percentage, root and shoot length, fresh and dry weight, vigour index, chlorophyll content, carotenoids, soluble protein, soluble sugar etc. The allelopathic effect of these species on different crops is due to its allelochemical like different phenolic compounds, tannin, oils etc. The degree of inhibition was dependent on concentration of allelochemicals. Some level of concentration also show the positive effect whereas most of allelochemical shows negative effect.

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ACADEMIC YEAR : 2104-15

Seminar No.14

Speaker: **Mr. Balvant R Ahir**	Reg. No. 2030313001
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. Manmohan J Dobriyal**	Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 06/08/2014

PRODUCTION OF QUALITY PLANTING MATERIAL FOR AGROFORESTRY

Rising human population leads pressure on forest to fulfill different needs like timber, furniture, fuel wood, fodder, food and raw material for various wood based industries. Thus growing trees with quality planting material in agroforestry is only option to meet forest products demand and to bring tree cover around 33%. The present total forest & tree cover is 78.92 Mha (24.01%) which constitute Forest cover- 69.79 Mha. (21.23%) and Tree Cover- 9.l3 Mha (2.78%). Agroforestry cover (Tree green cover)- 11.16 Mha with wood volume- 1.23 M cub.m and carbon storage of 280 tons (FSI, 2013). Plant quality means the freedom of plants from harmful and / or designated plant insect pests and diseases.varietal purity and general health condition and planting quality means the combined indices which define the value of seed for planting. The growth and productivity of agroforestry tree species remain adhered with various challenges and constraints and it could not attain the reliable level. Because of poor quality planting material, disease and pest problems, lack of proper nursery techniques for rising planting stock, etc. In the intensive management it is very important to develop fast and economical methods of raising superior quality planting stock. It may be from seeds, vegetative propagules, clones of good genetic material using rooting hormones, biofertlizers, media composition that support gro-wth of plant, and different propagation techniques which produce best individuals for high survival and growth. Its overall goal is to raise the physiological and phyto-sanitary quality of the plant reproductive materials available to masses and as a consequence, to increase the ecosystem production and productivity.

Brief Review of Research Work:-

Vimla Devi, *et al.* (2014) reported different tree improvement studies on 45 tree species used in agroforestry which shows majority of work on provenace , CPTs ,CP, *in vtro* regeneration, genetic diversity & molecular markers. She also reported more than 40 tree species germplasm selection in agroforestry species by different government institutions. In *Pongamia pinnata* there are 40 genotype selections by different institutes some which are still in zonal trials.

Hossain, *et al.* (1996) examined that the growth performance of twelve provenances offour Eucdlyptus species at the age of 1.5 years after out planting the provenance No 18604-Queensland of Eucalyptus camaldulensis and No. 17964- Queensland of *Eucalyptus tereticornis* have shown best performance among all the provenances of four Eucalyptus and considered as a promising species-provenances for this hilly areas.

Azamal Husen, (2008) observed that significant clonal variations on percent sprouting,percent rooting and mean number of roots while length of root per cutting was insignificant. The C3 (Tulsipur, UP) and *CLf* (Laxmipur, UP) clones have shown the highest percent sprouting, percent rooting and more number of roots and statistically same. The lowest rooting response was recorded in cuttings of C9 clone (Jammu, J&K, India). Application of 2,000 ppm IBA to cuttings of *D. sissoo* had significantly increased percent sprouting, percent rooting, mean number of roots and their length per cutting The shoot cuttings taken from C4 clone and treated with 2,000 ppm IBA have shown the highest number of roots (8.23) followed by C3 clone (7.62) from cuttings taken from the C9 clone of *D. sissoo.*

Azamal Husen, (2013) carried research to explore clonal propagation techniques by using moderately hard stem cuttings. The cuttings obtained from 20-year-old donors, namely FG I and FG 11, were treated with various concentrations of IBA, inserted into vermiculite, and cultured in a mist chamber at 32/26°C (day/night) and 85 ± 2% relative humidity. After 60 days, FG 1 clone was found superior in comparison to FG 11 clone in terms of sprouting percentage, rooting percentage, roots per cutting and root length in teak clone.

Sachs, *et al.* (1988) found the maximum root %, No., and total length in stem diameter 2, 3.5, and 12.5 respectively, as well as maximum root% in IBA treatment 3000 & 50000 and root No. in treatment 8000. he also found good root spread and root % in clone 0-12 and 0-8 respectively.

Dhillon and Sidhu, (2010) noticed that significant difference among clones for all growth trait CDBH, Height, and volume per tree) except for height at 6-year. No clone was significantly superior to control for any growth trait for age 4 and 6 year. Clone IN-CSb was promising given higher volume (0.56)/m2/tree at 8 year age.

Warrier, *et at.* (2010) found early growth comparison between seed raised and clonally propagated *Casuarina equisetifolia* and it's clearly indicated the superiority of seedlings over rooted cuttings at the age of 3 year under controlled condition.

Kanwar, (2010). Reported maximum rooted cutting %, No. of main roots, sprouted cutting %, and shoot per rooted cutting in treatment T2 (IBA 500 mg·\Khatry, (2006) found the maximum' establishment %, Length of longest shoot, No. of leaves and minimum day taken for bud sprouting in treatment 10 (1.0 mg/I BAP and 1.0 mg/l KN).

Chaudhari, (2012) noticed maximum plant height (ern) after 30, 60, 90, 120 and 150 day after showing in treatment T10.

Parthiban *et at.* (2013) evaluated that among different cutting sizes, the cutting size of 20 mm-25 mrn expressed early superiority in terms of plant height (184.58 ern), diameter (80.63 ern), and number of branches (6.20) of Jatropha cuttings at 3 month interval up to one year under nursery conditions.

Makwana, (2011) examined Effect of plant growth regulators and type of cutting (i.e. soft wood, semi hard wood and hard wood) on survival percentage in *Eucalyptus teriticornis* and he found maximum survival % in treatment TS (lBA-4000 ppm). Sofi, (2009) found the maximum survival % in soft wood, semi hard wood and hard wood, in treatment TS (IBA- 2000ppm) in *Derris indica.*

Patel, (2006) found that potting mixture of sand: FYM (1:1), that is T2 treatment gives more germination % as compare to other potting mixture and also tack minimum days for fully germination of *Terminalia bellerica.*

Mehta *et al* (20 l3) found that increase in proportion of sand in the soil mixture (1: 1 to 1:2 soil and soil ratio) showed increase in seedling growth. However, seedling assumed rapid growth when FYM was added to the soil having greater amount of sand (1:3:2; soil: sand: and FYM).

Uddin, *et al.* (2012) revealed that seedling growth were enhanced significantly with different treatment containing higher proportion of organic fertilizer, where nodule no. and size was inhibited significantly by the application of organic fertilizer in *Acacia mangium, Acacia auriculiformis, Albizia lebbeck, Acacia hybrid and Leucaena leucocephala.*

Bhasotiya, (2014) found that T7 (soil: sand: FYM (2:1 :2)) treatment gives higher survival % in all provenance of *Ailanthus excelsa* and he also found that provenance of Mehsana division gives best result among all treatments under nursery condition.

Saravanan, *et al.* (2012) conclude that the total biomass was highest in Frankia + Azospirillum + Phosphobecterium *(T7)* inoculated seedlings (48.23%) followed by Frankia + Phosphobecterium *(TS)* inoculated seedlings (41.73%) and Phosphobecterium (T3) inoculated seedlings (40.06%). Further, the growth parameters significantly increased in all treatments, compared to the control.

Yasin, *et al.* (2012) found that shoot length (20 em), root length (16 ern), shoot dry weight (947 mg /plant) and root dry weight (134 mg/ plant) were the highest in FYM medium with 20 mg P/ kg. The P concentration in shoot and root, total P uptake and P recovery were also significantly improved when plants were grown in FYM medium supplied with 20 mg P/ kg. It is concluded from this study that *L. leucocephala* seedling growth was improved with P application, particularly in FYM medium compared to clayey and sandy media. Further, the P level i.e. 20 mg P /Kg was found best among all P rates used. This shows the significance ofP and FYM medium in improving growth for the best survival of *L. leucocephala.*

Sondarva, (2014) recorded maximum shoot length, survival %, collar diameter and root length in treatment T9 (vermicompost: red soil (1: 1)) at 120 day after showing in *Khaya anthotheca* in nursery condition.

Agbogidi, *et al.* (2007) reported significantly higher height (39.8) and higher collar diameter (2.8) of teak seedling in TS planting media at 3, 6, and 9 week after transplanting.

Ferdousee, *et al* (2010) investigated that Seedlings raised in polybags of 23 x 15 ern size revealed best performance in respect to germination and other growth parameters. However, root-shoot ratio was higher in root

trainer in comparison to other treatments. Polybag size of 23 x 15 em was found suitable in the nursery for quality seedling production of *Leucaena leucocephala*

Conclusion

The reviewed information on QPM reveals that there is no sequential research/cohesive information available for any particular forestry lagroforestry tree species from elite germplasm /CPT selection- development of clone- standardization of propagation techniques or mass multiplication and growing media, disease and pest management grading- and then field performance. So the complete information in package form for QPM of particular elite germplasm or clone is scattered and so its application not yield good results ..

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Seminar No.15

Speaker: **Mr. Chavda Jayendrasinh R.**	Reg. No. 2030313002
Degree: M.Sc. Forestry (Medicinal & Aromatic Plants)	Course Code: FOR- 591
Major Advisor: **Dr. B. S. Desai**	Venue: Conference Hall
Minor Advisor: **Dr. S. K. Jha**	Date: 06/09/2014

ETHNOBOTANICAL STUDIES IN INDIA: AN OVERVIEW

The term Ethnobotany was first coined by Harshberger (1896). Since then many eminent scientists has defined ethnobotany. Schultes (1962), Father of World Ethnobotany defines it as the study of relationship that exists between people of primitive societies and their surrounding plant environment. According to Krauss

(1974), the term Ethno botany is derived from Ethnology which means the study of man and botany i.e., the study of the importance of plants to primitive people. According to Powers (1873:, In : Castteter (1944 cited by Cotton, (1997), the term Ethno botany is derived from the word "Aboriginal Botany", means the study of all forms of vegetation which aborigines used for commodities such as medicine, food, textiles and ornaments. Jain (Father of Indian Ethnobotany) in 1981 defined it to be the relationship between human society and plants. Ethnobotany/Ethnobiology is now a multidisciplinary studies comprising of allied branches like Ethno taxonomy, Ethno zoology, Ethno medicines, Ethno forestry, Ethno veterinary medicines, Ethno ecology, Ethno agriculture etc. (Jain and Jain, 2012). As per the latest census (2011) by Ministry of Home Affairs, Census Commissioner of India, there are 50 important nomadic tribes in India with more than 5 lakh population. Few of the important ones are Sahariya, Bhils, Gonds, Nagas, Khasi etc.

Review of Research Work:

Anonymous. (2000). All India Co-ordinated research Project on Ethnobiology was conducted over 27 centers in India involving 600 scientists. Over 9500 wild plants used by tribals for various purposes are documented, along with 3900 plants used as ethno medicines. Project was spear headed by Dr. P. Pushpangadan, who was the first to validate Kani tribal medicine (Jeevani & Arogyapacha made from the plant *Tricholepis zeylanicus subsp. travancoricus)* as immuno-modulator. Model rightly called as TBGRI or Kani or Pushpangadan model throughout India.

Jain and Srivastava (2011) have provided critical analysis of number of publications (1990 to 2010) in ethno botany w.r.t to specific diseases, dominant tribe and state wise contributions. Highest no. of disease wise publications is for family planning (20). Similarly, maximum publications (13) are on Sahariya tribe and leading state is U.P with total (80) publications.

Mohanty and Tripathy (2011) have given a totally new concept of ***toponyms*** in ethno botanical research in India. Study conducted in Jajpur district of Odisha reveals that there are many villages named after the genera of the specific families like Poaceae, Fabaceae, Areacaceae, Cucurbitaceae, Verbenaceae, Caesalpiniaceae, Moraceae, Combretaceae and Rutaceae with maximum of 12 % name of the villages named after the genera of family Poaceae.

Jain (2003) has provided with botanical analysis of leading plant families, whose plants are used in both EV medicines as well as Human Ethno medicines. Author has also provided with information on dominant genera with maximum species used by tribals of India for EV as well as Human ethno medicines. Notable 17 ethno medicinal plants used for treating more than 10 diseases in Cattles as well as Human beings are also documented. Leading families whose species are used in both EV and human medicines are Fabaceae, Asteraceae, Euphorbiaceae, Poaceae, Rubiaceae and Laminaceae. 97 species of Fabaceae are used for EV purposes, highest among all leading families. For human ethno medicines, total of 217 species of family Fabaceae is used by tribals, highest among all leading families. Genus *Euphorbia* and its 12 species is leading genera w.r.t to EV medicines, similarly genus *Poygonum* with 26 species is leading genera w.r.t to human ethno medicines. *Tinospora cordifolia* and *Azadirachta indica* are used for 22 diseases in cattles, whereas *Vitex negundo* is used for 42 diseases in Human ethno medicines.

Jain and Srivastava (1999) has also contributed to disease wise list of total species used by tribals in EV medicines. Maximum of 186 species is used for wounds and cuts in cattles, followed by 74 as Galactagogue, 70 in diarrhea, 58 in dysentery and 52 in healing bone fractures.

Jain (1991) has provided list of species used as remedies in Human Ethno medicines for major diseases in tribal of India. Out of these 520 species used as Edible, 309 species for Intestinal diseases, 288 species for Boils, 274 for Fever, 246 species for Injuries, 242 species for Pain relievers etc.

Mittre (1989) has provided a very comprehensive account of wild plants used by tribals in India as food – underground parts (80), leaves and shoots (250), flowers and inflorescences (55), seeds (150) unripe fruits (60) and ripe fruits (300). This review also gives view of plants used by tribals for hunting, fish poisoning and fishing, antidotes against various insect and animal bites, feeds and fodders for cattles, plants used as fibres (nearly 525 species), (70 species) used for making agricultural implements, (3500 species) used by tribals for medicinal purposes, out of which 950 are new claims and 300 are under ethno pharmacological validation. 61 species are utilized for dyeing purposes. Review also deals with emergency food among tribals of India, i.e. plant species

used during scarcity and famines. 44 species of wild plants are identified in this important category-one of the thrust area of modern ethno botanical research.

Jain (2003) has compiled few important species used only for specific disease and also species used for single diseases. Few of the examples are *Celastrus paniculatus* for Amoebiosis, *Lolium tenulatum* for convulsions and fits, *Catunaregum uliginosa* for Diptheria, *Gmelina asiatica* for Epitaxis, *Terminalia pallida* for Laminitis etc.

Desai (2002), conducted research on cross cultural ethno botany i.e. multiethnic uses of plants within Gujarat state. In all 261 ethno botanical plants were reported from Chhota-udepur forests division in Central Gujarat. On comparing with other tribal inhabited regions of Gujarat state, 120 ethno botanical plants (49.79 %) were found common between Dharampur and Chhota-udepur regions; 115 ethno botanical plants (47.71 %) common between Dangs and Chhota-udepur and 103 ethno botanical (42.73 %) common between Saurashtra & Chhota-udepur regions.

Jain (2011), reported few species common between different regions of World. Species such as *Dendrocalamus strictus* is used in both China & India; *Acacia sinuata* between Burma & India; *Ficus palmata* commonly used in Punjab, Mexico, Cuba & Sumatra; *Citrullus colocynthis* between India and Africa (Cape of Good Hope); *Sorghum halepense* and *Dinochloa scandens* in India and Philippines; *Echinochloa colonum* (Jungle rice) in India and Mariana Islands; *Panicum turgidum* in India and South Africa; *Digitaria exilis* and *Digitaria eburnea* are cultivated and consumed in both Africa and India; *Digitaria cruciata* var. *esculenta* is grown in both India and China, especially in India by Khasi tribes of Meghalaya for its grains. Wild forms of *D. cruciata* occur in mountainous regions of North West India and China, but the variety esculenta only occurs in Khasi hills of Assam, thus endemic to Khasia Jaintia hills of Assam.

Jain and Fernandes (1996) reported on plants commonly used by the tribals of India and Brazil; cross cultural ethno botanical studies between countries and found that there are in all 450 common species to both the ethnic regions, out of which 41 species are having common uses between Indian tribes and tribes living in Amazonian forests regions.

Arora (1996) and Nayar (2010), has given a review on utility and conservation of wild germplasm or wild land races grown and used by tribals of India. Few of the important ones are Sali and Verhi types of rice used in Western ghats and Malabar regions, Poorvi botapa, Murali, Tirap nag, Manipuri chujak, Mayang sach, Silken tipen, Khasi riewhdin, Nilap makop types of maize used in North Eastern tribal belts. Important wild varieties of millets are exclusively used by tribals of Central and North East India. Tribals in Peninsular region hold diversity in Black gram, Jack bean *(Mucuna utilis),* Lablab bean, Horse gram and chickpea. In North East region and Western and Eastern Himalayas, French bean, scarlet bean, rice bean and black gram. North Eastern and Peninsular tracts are also rich in diversity of vegetables. E.g. Cucurbits, bottle gourd, Chilli, Okra, etc, used by tribal. Few of the precious germplasm domesticated by Khasi, Garo and other tribes of North Eastern India are Tuberous legumes Sophlong and Millet Raishin, *Coix lacryma- jobi, Vigna umbelata, Phytolacca acinosa, Allium rebellum, Brassicas and Malva verticilliata.*

Conclusion:

Ethno botanical research is almost 06 decades old in India. From simple tribal uses of plants in early 60's, Ethno botanical studies has new expanded into thrust areas of Ethno pharmacological studies and Cross cultural Ethno botany. As per Jain (2010), nearly 1000 research papers, about 100 doctoral thesis and 50 books have been published in India on various aspects in ethno botany. Over 9500 wild plants species are used by tribal for various purposes in India. Out of 3900 wild plant spp. used by the tribal for medicinal purposes, 950 are found to be new claims, 300 of which are currently under Ethno pharmacological scrutinization. Dominant Genera is *Euphorbia* 12 species used in EV medicines and *Polygonum* 26 spp. used in Human Ethno medicines. W.r.t. No. of Animal diseases *Tinospora cordifolia* and *Azadirachta indica* are used for 22 diseases whereas in Human Ethno medicine *Vitex negundo* is used for 42 diseases. Nearly 155 plant species are mentioned in Folk songs, Folk proverbs and mythological beliefs of various tribals in India. Jajpur district of Odisha reveals that there are many villages named after the genera of the specific families out of which 12 % name of the villages named after the genera of family Poaceae.

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Seminar No.16

Speaker: **Mr. Dinesh Kumar**	Reg. No. 2030313003
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. N. S. Thakur**	Venue: Conference Hall
Minor Adviser: **Dr. S. K. Jha**	Date: 29/09/2014

ROLE OF WOMEN IN AGROFORESTRY

Women have been playing a vital role in progress of any civilisation in the world. They have considerable involvement in development of human race through participation in all sectors. Their importance in agriculture has immense importance too. Women are responsible for 70% of actual farm work and constitute up to 60% of the farming population (Chaudhary and Singh, 2003; Ahmed and Hussain, 2004). Women are traditionally the main collectors of fuelwood, medicinal and aromatic plants and other non-timber forest products (NTFPs) from forest and agroforestry landscapes (Shanley and Gaia, 2001). Their participation in decision making in agroforestry technologies, at household and community levels, although limited, however been demonstrated to improve forest regeneration (Agarwal, 2007, 2009) increase crop yields, improve financial management (Acharya and Gentle, 2006). Successes of many agroforestry projects have been attributed to women participation (Wambugu *et al.,* 2001). In most of the agroforestry activities women play greater role however; still they are lacking in marketing, trade and other agroforestry activities which involve greater technical know-how (Trinh *et al.*, 2005; Narasimha; 2008; Enete & Arnusa, 20 I 0). There are several such bottle necks, particularly biasness in benefit sharing even within one component ofagroforestry i.e. twigs and trunks (Chikoko, 2002). Considerable attention is required for their capacity building in agroforestry technologies

specifically processing, marketing, and activities requiring technical skills to empower them through this land use system (Komarudin *et al.,* 2008; Akhter *et al., 2010).*

Brief Review of Research Work:

Trinh *et al.,* (2005) reported that women contribute was more in species selection except fruit and ornamental crops compared to men.

Enete and Amusa, (2010) studied variations in contributions to food crop production activities decisions by women and men and found that contributions of women (LRS i.e. Likert Rating Scale, range is 2.48-3.19) to decision making in these activities were generally higher than male (LRS range 1.85-2.66).

Akinwumi *et al.,* (2000) determined the factors that influence the adoption of modifications in their management of alley cropping and its variants by farmers in the forest zone of southwest Cameroon and showed that the male farmers were more likely to adopt modifications than women. Modification which highly adopted by women were spacing between rows expanded (11.8%) and spacing between alley have expanded (11.8%).The reasons (91 %) attributed tor adoption of alley-farming technology was
improvement of soil fertility. The reasons were similar for both men and women alley farmers.

Dwivedi *et al.,* (2008) reported that women participate in all activities with maximum of manuring and harvesting (100%) and minimum in fertilizer application (17.5%). Further, it was observed that women spend maximum time in weeding (236.5 hrs. /year) and minimum in seed treatment (3.16 hrs.lyear). As regards the awareness level of farm woman about natural resources it was observed that maximum (67%) women are MPTS conservation concerned particularly for agroforestry and lowest recorded in nursery raising (27%).

Ojha *et al.,* (2012) studied the participation of farm women in Tea plantation activities in Nainital district (UK) and concluded that rural women (33%) were engaged in all activities, However, comparatively fewer women were involved in planting (26.61 %) and they spend maximum time in plucking of leaves.(1440 hrs/year).

Singh *et al.,* (2013) concluded that participation of rural women in homestead gardening was found to 60% and for men it is only 18.26% and women are performing all activities independently (50.74% - 64.27%). Independent role of rural women was found to be more than (50%) in soil treatment and plant protection. Marketing and management of cash is jointly performed.

Kasi, (2013) in a case study on role of women in Sericulture and Community Development, concluded that women play important role in all activities in mulberry garden maintenance with maximum in weeding and FYM application (84%) and no participation in ploughing and pruning. Women significantly participate in all silkworm rearing activities with highest (93%) in bed cleaning and lowest in brushing (26%).

Kiptot and Franzel, (2012) studied the financial benefits women receive from agroforestry products and revealed that women are benefited from the different products of different agroforestry species as surveyed by many scientists.

Conclusion:

Women have been playing an important in almost all agricultural activities since the binging of human civilisation.Women have maximum participation agroforestry activities except processing and trade. Studies suggested that women managed agroforestry technologies had greater success compared to their counterparts. They are considered integral part of project formulation and implementation. However, their participation, to some extent, is limited by socioeconomic, cultural and policy issues that vary across locations. Their role is minimum in activities requiring greater degree of technical skills e.g. fertilizer application, spray schedule, processing and marketing etc. Greater biasness can be seen in some societies in benefit sharing also. Hence, attention has to be paid for capacity building in agroforestry technologies specifically processing, and marketing to empower them through this land use system.

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Seminar No.17

Speaker: **Mr. Jay S. Modi**	Reg. No. 2030313004
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. M.B. Tandel**	Venue: Conference Hall
Minor Adviser: **Dr. V.M. Prajapati**	Date: 29/09/2014

IMPACT OF INTEGRATED NUTRIENT MANAGEMENT (INM) IN NURSERY AND PLANTATION OF FOREST SPECIES

Role of inorganic fertilizer in boosting the growth of forest tree species either in nursery or plantation in terms of girth, height and also biomass increment has been studied in several tree species (Totey *et al.* 1997). However these fertilizers are costly and cumbersome to use over vast plantation areas besides causing soil pollution if not judiciously used (Prasad, 1988). This age of increasing prices along with the increasing demand of chemical fertilizers and deleting soil fertility necessitates the integrated nutrient management involving biofertilizers. The process of inoculating microbes to the soil in a forest nursery could be an effective method to achieve higher growth and establishment of tree species on afforestation sites. Since application offertilizer in forestry operation is minimal or nonexistent, development of a proper poly-mix (combination of microbial isolates and organic fertilizers) for use in nursery could be a cost effective process.

What is INM? Integrated nutrient management is the maintenance or adjustment of soil fertility and plant nutrient supply at an optimum level to sustain the desired crop productivity.

Review of Research Work:

Nursery:

Paroha *et al.* (2009) stated that triple inoculation of PSB+ *Azotobacter* + NPK enhanced shoot height (29.40 ern), dual inoculation of PSB + *Azotobacter* increased root length (42.50 ern) and AM + Azotobacter increased collar diameter (1.35 ern) and biomass production (45.18 g/pl) in *Tectono grandis* Linn.f., Moreover, inoculation of AM + *Azotobacter* was found nearly 400% effective.

Dubey *et al.* (2006) found maximum germination percentage of *Acacia catechu* and *Acacia nilotica* by treatment with YAM + *Rhizobium i.e.* 66 and 52%, respectively. In case of *Buteo monosperma* 100 % germination was recorded in treatment combination of VAM + *Azotobacter* + PSM + *Rhizobium* +Blue green algae and in *Pongamia pinnata* same was found with VAM combination.

Revathi *et al.* (2013) studied integrated nutrient management on the growth enhancement of *Dalbergia sissoo Roxb.*seedling and concluded that dual inoculation with bio-fertilizers *(Rhizobium* + AM) and application of 5 ppm / Seedling of Fe significantly improved shoot length of shish am.

Dash *et al.* (2013) concluded that inoculation of different fungal and bacterial strains resulted in enhancement of plant height as compared to control. The application of *Aspergillus* sp. showed maximum plant height (145.66 ± 11.76 cm) as compared to other treatments whereas inoculation of *Penicillum expansum* exhibited good root growth (21.41 ± 3.16 cm). However, no significant difference was observed in the number of leaves between control plants and those in other treatments except for plants inoculated with *Aspergillus* sp. which showed highest number of leaves (115.0 ± 27.87). The collar diameter (42.66 ± 4.93 ern) reported maximum in plants inoculated with *Penicillium chrysogenum.*

Navale and Channabasappa (2013) stated that appl ication of *mycorrhiza* (5 g) + NPK (1: 1 :1) along with Soil: Sand: FYM (2: 1: 1) significantly increased seedling height, collar diameter, number of leaves, total fresh weight and dry weight in *Hydnocarpus pentandra.*

Kumar *et al.(20*13) revealed that combined effect of inoculation of *Rhizobium* along with· lower level of Nitrogen showed maximum seedling height, No. of leaves per seedling, root length and No. of branches per seedling over only organic application and control in *Dalbergia sissoo.*

Sankanur and Shivanna (2010) studied the effect of integrated nutrient management on growth and development of the *Pterocarpus santalinus* (Linn. F) seedlings and found that 33 g of poultry manure per seedlings gave significantly maximum seedling height, collar diameter, total fresh weight and dry weight (42.50

cm, 4.92 cm, 11.26 g and 4.23 g, respectively) whereas maximum root length (38.39 cm) was reported in Phosphobacteria @ 5 g per seedlings.

Sarvanan *et al.* (2012) revealed that triple inoculation of F + A + PSB increased N, P and K content in plant as well as seedling quality index *ofCasuarina equisetifolia* followed by dual and single inoculation.

Plantation:

Korwar *et al.* (2009) found that application of Vermicompost increased percentage of height and DBH increment 35.7% and 40.8 %, respectively in *Leucaena leucocephala.* Maximum mean height and DBH was recorded in V + IF i.e. 8.78m and 7.52 cm respectively.

Brahmi *et al.* (2010) concluded that alone application of Biofertilizers don't prove to be much effective but triple application of $N_{17.5}P_{33}$ mg/root trainer + VAM + *Rhizobium* showed better performance in comparison to other treatments for raising quality planting material of *Acacia catechu.*

Dubey *et al.* (2006) reported significant improvement in the growth of all four plant species in all bio-fertilizer combinations over control. In case of *Acacia catechu* the best growth was observed with combination of VAM+ *Rhizobium* (48.94 cm), in *Acacia nilotica* it was observed with VAM + *Azotobacter* (68.75 cm), in *Butea monosprma* it was found maximum in combination of VAM + *Azotobacter* + PSM + *Rhizobium* +Blue green algae (25.76 cm) and in *Pongamia pinnata* showed better performance with VAM combination (26.56 cm).

Jaisankar *et al.* (2013) studied the response of *Dalbergia sissoo* Roxb. Clones to integrated nutrient management practices and they found that combined treatment of 125 % of STY (Soil Test Yalue) 138:98:65 NPK kg/ha + VAM (100 g/plant) + *Azospirillum* (50 g /plant) + *Phosphobacteria* (50 g/plant) + FYM (500 g /plant) recorded significantly maximum height, basal diameter, branches and leaf area of *Dalbergia sissoo* as well as organic carbon, avai lable nitrogen, phosphorus, , potash of soil during the initial growth stages (180 DAP).

El-Quesni *et at.* (2013) stated that all treatments significantly promoted all growth parameters of *Jatropha curcus* L. seedlings then control plants. The highest values of plant height, stem diameter, number of leaves/plant, leaf area and root length of *Jatropha curcus* were obtain by application of algae.

Bhattarai and Tomar (2009) worked on effect of integrated nutrient management on leaf nutrient status of Walnut *(Juglans regia* L.) and concluded that recommended dose of NPK + 50kg vermicompost and three fourth recommended dose of NPK+68.75kg vermicompost were effective for improvement of leaf nutrient status.

Jaisanker *et al.* (2014) revealed that 125 % ofSTV (Soil Test Value), 138:98:65 NPK kg/ha + VAM (100 g/plant) + *Azospirillum* (50 g Iplant) + Phosphobacteria (50 g Iplant) + FYM (500 g Iplant) recorded signi ficantly maximum height and basal diameter of *Dalbergia sissoo* when intercropped with cowpea *(C2).*

Mohan and Radhakrishna (2012) conducted an experiment on screening of phosphate solubilisng bacteria isolates for the growth improvement of *Tectona grandis* Linn. and concluded that application of both the isolates (Isolate 10 = KED-4 *(Bacillus subtilis)* and Isolate 17 = TCO-6 *(Pseuodomonas fluorescens)* together not only enhance the growth but also increased the biomass and the quality of the plantlets.

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Seminar No.18

Speaker: **Mr. Avinash G. Parmar**	Reg. No. 2030313005
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. N.S.Thakur**	Venue: Conference Hall
Minor Adviser: **Dr. S.K.Jha**	Date: 18/10/2014

HOMEGARDEN: DIVERSITY AND BENEFITS

Homegardens are traditional agroforestry systems characterized by the complexity of their structure and multiple functions (Das and Das, 2005). These are, presumably, the oldest form of managed landuse systems next only to shifting cultivation (Kumar and Nair, 2004). Homegardens are defined as land-use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural ctops and invariably livestock within the compounds of the individual houses (Fernandes and Nair, 1986). Homegardens are dynamic in their evolution, composition and uses. Besides ensuring a diverse and stable supply of socio-economic products and services such as food, medicine, firewood, fodder, timber, etc. to the families, that maintain them, home gardens are also recognised as important *in situ* sites of biodiversity conservation, especially of agro biodiversity. They also invite the attention of researchers as interesting models of sustainable agroecosystems characterized by efficient nutrient recycling, low external inputs, soil conservation potential, eco-friendly management practices, etc. (Torquebiau 1992; Jose and Shanmugaratnam, 1993). In India, research on home gardens have been mainly concentrated in Kerala (Kumar et al. 1994; Puskaran 2002), Assam (Das and Das. 2005) and Andaman islands (Pandey *et al.*, 2006, 2007). In south and north east India these production systems have been reported as repository biodiversity, providing multiple tangible and non tangible benefits.

Brief Review of Research Work:

Diversity

Kumar *et al.,* (1994) recorded a tremendous variability in the number of taxa present in the homesteads. Aggregate number of species per Panchayath ranged from 155 to 319 (52-125 herbs, 32-70 shrubs, and 66-146 trees. Also together 463 species were recorded from all selected Panchayaths in the three selected districts, of which 208 were trees, 86 shrubs, and 169 herbs.

Bhat *et al.,* (2014) in their study on home gardens of Karnataka, size ranging from 0.01 ha to 0.05 ha (the average size being 0.02 ha) recorded a total of 210 species of flowering plants from the 50 homegardens. Life-form analysis of the plant species indicated that shrubs were the predominant forms with 73 species, which account for 35% of the total recorded species. There were 61 trees species (29%),42 herbs (20%) and 34 are climbers (16%).

Devi and Das (2012) carried out survey of 50 home gardens in Barak valley, Assam and reported 71 trees, enumerated from 50 HGs, belonging to 60 genera, 35 families. Among the families encountered, Rutaceae was the dominant family followed by Meliaceae, Arecaceae and moraceae.

Saha *et al.,* (2009) studied richness in large and small homegarden in madakkathra panchayat, thrissur, kerala, India and reported higher species and plant density in small home gardens.

Tynsong and Tiwari (2010) investigated the plant species diversity in homegardens of War Khasi community of Meghalaya. In total, 197 plant species were recorded with an average of 89 plant species per homegarden (Av. Size of home garden was 750 m^2).

Suba *et al.,* (2014) investigated the vascular plant species composition of homegardens maintained by the Kani tribe of Kanyakumari wildlife sanctuary and encountered 368 plants belonging to 290 genera and 98 families, which included 118 tree species, 71 shrub species, 139 herb species, 45 climber and 5 twiners.

Zimik *et al.,* (2012) investigated species diversity in the homegardens of Assam and Arunachal Pradesh. High diversity of plant species is recorded in studied homegardens with a total of 268 species (107 trees, 53 shrubs and 108 herbs) belonging to 200 genera under 82 families. Species richness per homegarden varied greatly and it ranged from 25 to 87 with an average of 46 species.

Saikia *et al.,* (2012) conducted survey of 80 homegardens in 17 villages of Golaghat and Jorhat districts of Upper Assam. Altogether, 294 plant species representing 217 genera and 92 families were encountered.

Arunachalam *et al.,* (2007) conducted a study in the homegardens sites. In most of homegardens the top storey was occupied by *Areca catechu* Linn. *Artocarpus Mangnifera,* etc. dominant in the sub-canopy. Papaya,Guava and Citrus were common in middle storey.

Peyre *et al.,* (2006) studied based on structural and functional characteristics and dynamics, the different homegarden categories i.e. Traditional, adapted, incipient modem and modem and found that first two categories have high diversity, and later two less.

Devi and Das (2005) conducted a study in the homegardens (36) of Meitei community, Rajubari, Assam, India and reported totaln spp., out of which 38, 10 and 44 were trees, shrubs and herbs.

Kumar (2011) studied floristic diversity of medium, small, and large sized home gardens and average number species were 145,173, and 138, respectively.

Benefites

Thaman (1995) reported distinct varieties of food plants found in homegardens systems in different Pacific islands.

Winkler *et al.,* (2010) studies the homegardens and categorized the plant species on the basis of use and services they provide. On average each homegarden contained about 42 plants out which 16 were fruit trees or shrubs, nine vegetables, eight medicinal plants, seven ornamentals, and two other plants such as rubber or timber.

Nair (2001) found that several of the tree fruits in the gardens are nutritionally richer than the common, carbohydrate-rich grain crops, and are indeed the main sources of vitamins and minerals to the family .The cash-income opportunity offered by saleable products (especially tree products) from the homegardens make it an attractive proposition for men too.

Zaman *et al.,* (2010) in their study in Thakurgaon, Bangaladesh, reported that small and marginal farm owners are getting most of the share of their total income from hornegarden.

Landreth *et af.,* (2014) reported that in Sri Lanka, 25 per cent of the total income is from homegardens and maximum contribution, among homegarden components, is from spices.

Arunachalam *et al.,* (2007) studied the variation of litter and tine root biomass in hornegarden and reported litter carbon stocks ranging from 0.30 to 0.75 tlha. Further, the fine root carbon stock decreased with depth (0.15 and 15-30 cm) whereas, course root carbon stocks increased with depth.

Saha *et al.,* (2009) conducted study of soil organic carbon content across soil depth and plant species density in homegarden with different plant species densities in Thrissur, Kerala, India. The results revealed that sac increased with plant species density.

Conclusion:

Homegardens are recognised as important sites of biodiversity conservation, especially of agro biodiversity. The homegardens in south and north Indian states are rich in biodiversity. Besides ensuring a diverse and stable supply of socio-economic products and service; such as food, medicine, firewood, fodder, timber, etc. to the families that maintain them, they also a good sink for carbon dioxide. These oldest systems besides source of multiple products for family consumption could act as cash oriented production systems depending upon the type. Sometimes, these homegardens contribute less to the income however, in some situation contribution could

be substantial i.e. act as major source of income. Thus, these production systems are storehouse of biodiversity satisfying diverse needs of the households.

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Seminar No.19

Speaker: **Mr. Vasava Miteshkumar Sureshbhai** Reg. No. 2030313006
Degree: M.Sc. Forestry (Agroforestry) Course No: FOR-591
Major Adviser: **Dr. V.M. Prajapati** Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel** Date: 18/10/2014

DISEASES IN FOREST NURSERIES AND THEIR MANAGEMENT

Most of the plants for the reforestation are planted from the seedlings multiplied in the nurseries at distinct locations. Seedlings are usually grown in extensive monoculture practices in either small open area or greenhouse. Environmental as well as micro environmental conditions within nurseries are often appropriate for the multiplication of pathogens, due to dense plantation, high moisture content and nutrients supplied to the nursery seedlings. Infection in the nurseries may increase chances of spreading and establishment of the diseases in the area where it is not available from the area where it is commonly available or widespread. Once the diseases get established in the forest nursery, it causes enormous losses and many diseases are practically impossible to eradicate. Diseases are the major contain in forest nurseries to develop healthy seedling that's why to manage the diseases are essential. So many diseases occurred in forest nursery *viz.*, Anthracnose, Bacterial Canker/ Blight, Leaf blight, Downy mildew rust, Damping off, Stem rot/ foot rot/ collar rot, Leaf spot, Wilt, Dieback. Among them damping off disease is most prevalent in forest nursery (Kumar, 2014).

Therefore, production of healthy disease free saplings in the nursery is of immense importance. Among the various agroforestry systems quality seedlings remain a bottleneck in the success of these agroforestry models on farmer's field. Therefore, planting healthy and well grown seedling in the field essential for the success of any agroforestry model and to raise such material an establishment of well managed nursery require (Kumar, 2014). Following review supported my theme presentation by which we can know the status of forest nursery disease and now it will be manage.

Brief Review of Research Work:

Occurance of the disease:

Uniyal (1999) observed the mortality of the *Azadirachta indica* seedlings at Satyanarain nursery by the collar rot disease and observed mortality up to 66% in seed origin from Sangli (Maharashtra) and 40% in Baliya (Uttar Pradesh) rest of the seed origin shows 3-20% mortality.

Kaushik *et al.,* (2000) isolated 12 fungal spp of different tree spp and reported that *Fusarium* and *Rhizoctonia solani* were most prevelent and caused more than 50% mortality in Neem, Shisham, Jatropha and *Cassia* Spp.

Dadval and Jamaluddin (1996) studied the pathogenicity test of root rot of *Boswellia serrata* and reported that number of infected seedling and disease percentage were high in soil mix mcontaining [Nursery soil + Sand + FYM (2:1:1)] as compared to sand and black cotton soil.

Singh (2002) proved that disease incidence in leaf spot, leaf blight in *Gmelina arborea* and leaf blight in *Dipterocarpus macrocarpus* was 95%, 80% and 73%, respectively whereas disease severity of leaf spot, leaf blight in *Gmelina arborea* and leaf blight in *Dipterocarpus macrocarpus* was 35%, 29.2% and 40.8%, respectively.

Sharma *et al.,* (2002) revealed that clones, which were disease free during July, got infected in the month of august. Clone Kufri has least disease while clone Theog was most susceptible. Disease development rapid between july and august month. They also studied the leaf rust disease response of different hybrids of *P. ciliata x P. maximowiczii* and concluded that PCM 5195, 5011, 5180 and 5157 hybrids had least disease and PCM 5084 and 5053 were highly susceptible.

Verma (2013) conclude that the root rot disease of teak seedling was developed due to water stress condition in nursery soil because of high temperature sustained for a comparatively longer duration during summer.

Management of the diseases:

Uniyal *et al.,* (2004) recorded the percent increase in infection index after application of fungicides in *Acacia nilotica* seedlings. All the treatment showed considerable reduction in canker formation as compared to untreated seedlings. Best control of canker formation was obtain by spraying mixture of 0.2% Devistin and 0.1% Tgacop followed by mixture of 0.1% Devistin and 0.1% Dithane M-45 in *Acacia nilotica* seedlings.

Uniyal (1999) studied effect of fungicides on the growth of *Fusarium semitectum* of collar rot of *Azadirachta indica* and revealed that Bavistin and Ziram were most effective fungicide then other fungicide.

Dadval and Jamaluddin (1996) studied effect of fungicides on seed germination & disease development in *B. serrata* and revealed that thiram and toposin were more effective in control of disease development followed by Bavistin, Dithane M-45, Ceresen and P.M.A out of seven fungicides. The fungicide Toposin proved best enhance the germination up to 36% then untreated seeds.

Kaushik *et al.,* (2000) concluded that both fungal biocontrol agents checked more than 50% growth of pathogen. *Pseudomonas fluoresescens* was more effective than *Becilus subtilis*. However *Beccilus subtilis* effectively controlled the growth of *R. solani* and *F. moniliforme*.

Dadval and Jamaluddin (2003) studied antagonistic activity of *Streptomyces sp*. on and revealed that maximum inhibition zone 15mm recorded from *Sarocladium oryzae* causing seth blight in *B.nutans* and *D.asper* the *Alternaria alternata* causing leaf blight in *Gmelina arborea* and Bacteria *(Xanthomonas)* causing leaf curling and top dying in *Tectona grandis.* They also studied effect of *Streptomyces* on growth and biomass of inoculated and uninoculated seedling of leguminous tree spp. and revealed that Shoot length, Root length, Fresh shoot weight, Fresh root weight, Dry shoot weight, Dry root weight and no. of nodule found maximum in *Streptomyces* inoculated seedling of *A.lebbeck, A. procera* and *D. sissoo* as compared to uninoculated seedling.

Singh and Jamaluddin (2000) found that biofertilizers like VAM fungi and Rhizobium along with antagonistic fungus *Trichoderma viride* was highly effective in controlling the root rot problem of *A. nilotica* caused by *F. pallidoroseum.*

Dadval and Jamaluddin (2010) proved that the seed treated with the culture of bio-control agent (*B. firms*) did not show any fungal flora during germination and at same time percentage emergence of treated seedling also high, the seedling of *A. procera* and *A. lebbeck* inoculated with *B. firms* did not show any mortality, which proved that the application of *B. firms* could be used as bio-controlling agent against post emergence damping off disease in forest nurseries.

Conclusion:

At seedling stage plants are highly susceptible to diseases *viz.,* Damping-off, Collar rot, Root rot, Leaf blight, leaf spot, Wilt and Die back are wide spread disease occur in seedlings. These disease caused 3-65% mortality in seedling of various tree species. Disease in forest nursery can be controlled by spraying of various fungicides *viz*., Bavistin, Devistin, Tagcop, Dithane M-45, Ziram, Toposin etc. with the use of bio-control agents *viz., Trichoderma hazianum, Trichoderma viride, Beccilus subtilis, Pseudomonas fluoresescens, Streptomyces sp., Beccilus firms etc.* diseases in forest nurseries can be managed.

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Seminar No. 20

Speaker: **Mr. M.R.Nayak**	Reg. No. 1030313002
Degree: Ph.D. Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. D.B. Jadeja**	Venue: Conference Hall
Minor Adviser: **Dr. D.P. Patel**	Date: 29/11/2014

JFM: A TOOL FOR ECOSYSTEM CONSERVATION AND SUSTAINABLE USE OF FOREST RESOURCES IN INDIA

Joint forest management (JFM) is a concept of developing partnership between fringe forest communities and the forest department on the basis of mutual trust and jointly defined roles and responsibilities with regards to forest protection and development. The effective and meaningful involvement of local communities in sustainable forest management is the main approach to address the long standing problems of deforestation and land degradation. Moreover JFM is a decentralized and people oriented forest management approach, which is being promoted in India since 1990. The approach lies in the assumption that only a willing and active partnership between the Forest Department and local village communities can promote regeneration of degraded forests and conservation, sustainable harvest, use and management of forest resources. The forest, which used to be a major resource in the past, are now not able to meet even the basic needs of forest dependent communities. It is increasingly recognized that participation of people in forest management not only contributes to regeneration of degraded forest, but also helps in cost-effective conservation of the forest, apart from meeting the community's subsistence needs. Efforts at involving local people in management of forest resources have produced encouraging results with respect to forest conservation and regeneration. In India 28 states have formally initiated JFM, with their respective State Forest Department issuing orders in the form of resolution, to enable the constitutions of Forest Protection Committees (FPCs). As on 2013, JFMC covers more than 22 million hectares of forest spread which is more than 18% of the total forest of India. (MoEF, 2013)

Brief review of research work:

1- Ecosystem Conservation

Behera and Sinha (2012) revealed that UJFM (Universalization of Joint Forest Management) had the maximum in species density/ ha (906), percentage of tree girth class distribution (56%), basal area (118.00 m^2/ha) and standing biomass (6747.2 tons/ha) respectively as compared to other JFM models.

Razvi *et al.* (2011) reported that 58 Village Forest Committees (VFCs) engaged in different JFM activities like natural regeneration, artificial regeneration and pasture regeneration of Kamraj Forest Division of Kashmir Valley.

Hegde *et al.* (2011) reported that the species richness decreased over the five year period. But the numbers of recruits increased from 31 to 39 over the same period. Among the JFPM villages, highest loss of planted species is observed in Nidgod (60%) and least loss (10%) is observed in Hallibailu, Similarly the number of natural species decreased in 3 villages (Gornemane, Illimane, Hukli), increased in 2 villages (Hallibailu, Kadle) and remain constant in Nidgod village.

Murali (2002) reported that all the state indicates positive trends of regeneration in the JFM sites. The regeneration density (8914.67) and recruitment density (1380.83) were found maximum in the JFM sites of West Bengal. Similarly multipurpose local need species with 47.03% in JFM areas and firewood and miscellaneous species with 66.10% in Non-JFM areas preferred in afforestation strategies.

Baria and Kiran (2012) reported maximum species frequency (31), species abundance (7.01) and species density (1990/ha) in JFM forest areas as compared to the natural forest. Again revealed that species richness and diversity index were found maximum of 14 and 0.99 respectively in JFM forest areas.

Sreedharan (2002) found that the tree density and average height of trees increased after JFM implemented areas *i.e.* maximum of 60% and 37% respectively. Similarly there is maximum increase in diversity of trees, shrubs and herbs of 36%, 61% and 91% respectively in the JFM implemented areas.

Ghate and Ghate (2010) concluded that JFM implemented village Talwada had highest stand basal area (19.74 m^2/ha) stems per plot (9.63) and mean height of tree (13.8 m) as compared to other villages, thus secured the highest forest score of 43.17.

Gupta *et al.* (2004) reported that there is improvement in ecological conditions of JFM villages in terms of forest regeneration, biodiversity, productivity of forests, water conservation, availability of fuel and fodder as well as wildlife.

Singh (2008) stated that highest stocking (trees/ha) and total volume MAI (m^3/yr/ha) of 6300 and 12.5 respectively in Chuinara JFM protected area of Bolangir forest division.

Maiti *et al.* (2008) found in rehabilated site of JFM that, the diversity index as well as number of species was in increasing trend *i.e.* from 2.49 to 2.58 and 14 to 34 respectively as compared to degraded site.

Tiwari *et al.* (2000) compared the Importance Value of Index (IVI) between zero year and three year protected forest areas and found *Shorea robusta* and *Hollrahena antidysentrica* with highest IVI value of 129.7 and 192.7 in three year and zero year protected areas respectively.

Gupta (2007) concluded that the average content of Organic carbon (0.38), organic matter (0.65), total N 0.09), K_2O % (0.22) and P_2O_5 % (0.10) of Pawra village under JFM were more as compared to these in the Non-JFM village of Saketnagar.

Sreedharan (2002) reported increase of water table in the watershed after JFM implementation. Similarly the incidence of fire was negligible in the JFM protected areas.

2- Sustainable use of Forest resources

Behera and Sinha (2012) stated that there is increase in NTFP collections and decrease in fuel-wood collections in all the divisions of forest after adoption of JFM models. The change in increase range of NTFP collections is 03 kg to 08 kg where as decrease in fuel-wood collection range is -3 q to -8 q.

Batabyal *et al.* (2011) found that poor, very poor and middle class household were benefited through selling of NTFPs. The poor, very poor and middle class households got total income from NTFPs with maximum of Rs. 9300, Rs.17050 and Rs. 27300 respectively.

Mishra *et al.* (2001) stated that biomass productivity/area of fuel-wood species and enthobotanical species were maximum of 5812.95 kg/ ha and 284 kg/ ha respectively in fenced condition. The fuel-wood species *Combretum roxburghii* contribute maximum with 5346.37 kg/ ha and enthobotanical species *Bassia latifolia* with maximum 226.30 kg/ ha biomass in the fenced condition.

Ray (2002) revealed that maximum quantity of NTFPs was collected in the categories of fuel-wood (1250 kg), thatch (700 kg), fodder (400 kg), edible herbs/tubers (50 kg), medicinal plants (12 kg), broom (70 kg) and bamboo (4500 kg) in a sustainable way at Melaghar, Tripura under JFM.

Rao *et al.* (2002) reported that fuel-wood species were planted in 49,973 ha area and out of which 12,050 ha area was handed over to VFCs for care. It was expected to produce 73,200 ton/ha/yr, which may fulfil the fuelwood demand of 36150 households (@ 2 ton/hh/yr).

Singh and Sharma (2010) found that maximum number of households (253) benefited through NTFPs and fodder of 1000 quintals of Vagheswary village. Whereas maximum employment (MD) was generated in the Odd village under JFM studied area.

Gupta *et al.* (2004) concluded that fuel-wood and fodder collection rate decreased after Participatory Forest Management (PFM) produces in both the Kodsi and Talaichittor village. The decreased percentage for fuel-wood is 75.8 and 55.3, where as for fodder it is 41.5 and 35.1 in Kodsi and Talaichittor respectively.

Tiwari *et al.* (2000) compared the NTFPs collected annually from the JFM managed forest and other forest and found collection of firewood and fodder were more from the other forests as compared to the JFM managed forest. However, in case of herbs, Mohanbhog village extracted 1784 kg/year from the JFM forest and only 802 kg/year from the other forest.

Bahuguna and Hillaluddin (2011) reported that different NTFPs like honey, tikhur and baichandi were collected. Before value addition collected quantity was around 38.7 q, 27.95 q and 45.0 q with the revenue of Rs. 231999.75, Rs. 8384.85 and Rs. 13500.00, respectively. While, after the value addition it was around 32.89 q, 2.0 q and 45 q with the revenue of Rs. 447357.15, Rs. 23999.85 and 120015.00 respectively.

Conclusion:

Forest is an important natural resource with multiple unconditional beneficial effects but due to unsustainable way of harvest and mismanagement the status of forest resource is decreasing at an alarming rate worldwide. Out of different strategies to conserve and protect forest, JFM is one which was adopted and practiced in India. The JFM was developed as a response to forest degradation and its impact on the ecology and livelihoods of poor people dependent on forests. Review showed that JFM conserves the forest ecosystem by reducing illegal cutting of trees, area under illegal encroachments, forest fire prevention and control and through afforestation program by community involvement as a result positive changes occur on soil quality and vegetation attributes viz., species richness, diversity, stem density, status of vegetation regeneration and biomass. Similarly it motivates the participation of people to collect and use the forest produce like fuel wood, fodder and other NTFPs etc. in sustainable way. Thus JFM in India is an attempt to reverse the process of forest degradation to conserve ecosystem on one hand and to meet people's need on the other hand in a sustainable way.

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Seminar No. 21

Speaker: **Mr. Jayesh Pathak**	Reg. No. 04-1318-2012
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. D.B. Jadeja**	Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel**	Date: 29/11/2014

BAMBOO BASED AGROFORESTRY

Bamboo is commonly known as "poor man's timber" and play a vital role in improving the socioeconomic status of rural population, The most traditional uses of bamboo include housing, food and other material for handicraft. Worldwide around 2.5 billion people trade in or use bamboo (INBAR, 1999). India is one of the leading countries of world, second to China in Bamboo production with 32.2 million tonnes per year.

Bamboo species cover an area of 10.03 million hectare with 22 genera and 136 species. They contribute 12.8% of total forest cover of India (Berry *et al.* 2008). Bamboo resources have considerably been dwindled from the natural habitat due to over exploitation, gregarious flowering, and extensive forest fire. Social and industrial demand of bamboo is increasing at faster rate than its supply. In order to achieve the targets of present and future demand, expansion of bamboo in non-forest area by adopting agroforestry is viable approach for conservation and sustainable utilization of bamboo resources. With view to this in India formation of National Bamboo Mission take place in 2006 under Ministry of Agricultural and Cooperation to increase bamboo plantation in non-forest area. Bamboo based Agroforestry is relatively a new area. The basic tenet of agroforestry is that polycultures can share in the resilience of natural ecologies; possible benefits for the farmer include wider economic opportunity, increased habitat for beneficial species, and lower management costs. By designing bamboo into mixed-use agroforestry complexes we can maximize its functionality while integrating it with other production crops. In agroforestry systems where each plant receives individual care, bamboo shows promising results. This system is especially important and significant for developing country like India. Under this system because of use of various intercrops, products are obtained even in the early stages of plantation and the income is much higher than any other system. Bamboo based agroforestry ensure us four securities i.e., Food security, Livelihood security, shelter security, ecological security and energy security and hence playing an important role in sustainable development.

Brief review of research work:

1. Food Security

A). By rejuvenating degraded land: Nguyen (2004) studied Bamboo-based AF systems in the upland fields in Dong Cao and Que Vai villages and found that intercropping with bamboo showed reduced run-off and lower erosion in comparison to similar agroforestry systems with *Acacia mangium* and *Tephrosia candida.* In that study bamboo accounted for a higher percentage of the income than did trees in the total household economy.

Bihari *et al.* (2000) studied environmental impact on bamboo cultivation and concluded that degraded agricultural land may be ecologically restored fast owing to the bamboo based agroforestry systems associate silvicutlure and agricultural operations.

B). By Reducing Soil erosion and water conservation: Wu *et al.* (2003) showed an average surface soil runoff per month in bamboo forests is only 0.10 m3/ha, which is equivalent to only 77% of the rate for the Chinese fir forest and 35% of the rate for the *Pinus massoniana* forest.

Zheng and Hong (1998) found that the ability of the Moso bamboo forest to stabilize soil (i.e., quantity of restrainting soil loss per unit area and per unit time) is 1.5 times that of the *P.massoniana* forest.They also found that the rainfall interception ratio (vegetation canopy intercepting/rainfall) of the Moso bamboo forest is 1.3 times higher than that of the Chinese fir forest.

Rao *et al.* (2012) studied Bamboo plantation interventions in degraded gully lands and observed that lowest runoff(8%) and soil loss (5.52 tlha) was recorded in W3 watershed i.e. (Bamboo plantation with earthen check dams made of sand bags) followed by WI watershed i.e. (Bamboo plantation with staggered trenches) in comparison to control watershed W4 (run off 29% & soil loss 15.57 t/ha) .

C). By intercropping: Rahangdale *et al.* (2014) studied the impact of bamboo species on grain yield of different Kharif crops under three year old bamboo based agrisilviculture system over sole crop and found that among different Kharif crop soybean (67.88%) and moong (61.30%) showed relatively higher reduction in grain yield as compared to til (49.2S%) and paddy (34.00%). They also studied impact of bamboo species on straw/stover yield (kg ha^{-l}) of different Kharif crops under agrisilviculture system over sole crop and found that among the four Kharif crops soybean showeds higher reduction in straw yield (49.22%), whereas the lowest was in paddy (19.78%) under three years old bamboo based agrisilviculture system over the sole crop i.e. without bamboo.

Bhol and Nayak (2014) studied yield of crops(q/ha) with and without bamboo in 2nd year kharif and found that irrespective of system/spacing, the yield was maximum under cowpea(17.87 q pod/ha) followed by blackgram seamum and greengram (5.05 q/ha). They also studied yield of crops(q/ha) with and without bamboo in 2nd year Rabi and found significant variation between crops irrespective of spacing/system. Higest grain yield (3.79 q/ha) was noticed in sunflower while lowest yield (2.56 q/ha) in black gram.

Tripathi *et al.(20*11) studied the yield of french bean, bhindi, colocassia, turmeric and ginger under 2nd year bamboo plantation at.different spacing and observed that French bean, bhindi, colocassia, turmeric and

ginger were found highest in control with 1.25 Kg/sq m, 2.1 Kg/sq m, 1.20 Kg/sq m, 1.15 Kg/sq m and 1.85 Kg/sq m. However, among the three species of bamboos, all crops yielded better when grown under *Bambusa tulda* (5m x 7m) followed by *Bambusa nutans* (5m x 7m) and *Bambusa balcooa* (5m x 7m).

D) Bamboo and Homegardens: Nath and Das (2008) studied Bamboo resources in the homegardens of Assam and observed that *Bambusa cacharensis, B. vulgaris,* and *B. balcooa* exhibited the highest frequency of occurrence both in the homegardens and bamboo groves signifying the villagers preference for these species. Relative Importance Value (RJV) also was highest for *B. cacharensis,* followed by *B. vulgaris;* and *B. balcooa.*

Krishnankutty (2004) reported the estimated benefit-cost ratio (B/C ratio) for different crops at various rates of land rent in Peringandur Village. At all rates of land rent, bamboo has the highest B/C ratio. In Peringandur Village, perennial cash crops have a lower B/C ratio even at 18% land rent. Even with a high B/C ratio for bamboo, other type of crops continue to be grown in the village.

E) Bamboo and Live-stock fodder: Paul *et al.* studied the nutrient analysis of selected bamboo species and found that all the five varieties of Bamboo showed a high level of crude protein. The crude fiber and crude protein content are good that they can be recommended as fodder for cattle in lean times. This may address fodder shortage in small livestock holdings in Kerala.

F) Bamboo and Poultry: INBAR (2012) reported that Feeding chickens on an organic diet containing fresh bamboo leaves results in them weighing up to 70% more than those fed on standard organic diets. The results suggest that the fibre in the bamboo leaves enlarges the digestive tract and enables the chickens to consume more and to grow faster. The graph of results shows a huge improvement in the weights of the chickens fed on bamboo, with them being 70% heavier by the fifty-sixth day.

G) *Bamboo and Vermi-compost:* Nath *et al.* (2009) reported that the Merino Farm at Gahr Mukteswar, UP is one agency that carried out bamboo agroforestry in a scientific manner. After 6th year of operation by Merino Century Laminating Co. Ltd., the net production was 370 t/yr and 45.856 t/yr for vermin-compost and bamboo culm with a net revenue ofRs. 2,51,600 and Rs. 83,667 respectively from 4.0 acres of plantation at 5m x 5m. After deduction of total plantation establishment and maintenance cost (Rs. 1,92,000), the net profit became Rs. 1,43,267 after 6th year. The consolidated profit for 7th year onwards was expected to be Rs. 3,35,267 ie., Rs. 83,817 per acre.

H) Edible shoot farming for health and nutrition: Kumar Muktesh (2009) studied the nutrient status of all the six species of bamboos and clearly indicated that the *D. strictus* is more nutritious than *D. hamiltonii* and *B. bambos.* He also recorded that the shoot production season is from June - September. The shoots can be harvested 7 - 14 days after the emergence when the shoot height will be about 15-30 cm depending upon the species and observed that 4-6 shoots were produced per clump at a time and of these 60 per cent of the new shoot can be removed for edible purposes.

2. Livelihood Security

Singh *et al.(2008)* reported the state wise production and costreturned analysis for edible shoots in NE states and reported that the net income appears to be Rs. 18.85 million/yr and Rs. 22.90 million/yr for fresh and processed bamboo shoots respectively in the North East region. NABARD has reported 'that average production of bamboo production from natural degraded land of one hactre is around 15t1ha from ninth year onwards which provide income of Rs 36000 annually.

3. Ecological Security

Amit Kumar and Srikanti Kumari (2010) studied the net photosynthetic rate and stomatal conductance of five bamboo species and observed that when compared to that of other fast growing species, it was found quite high in bamboos.

Agrawal and Purwar (2011) studied carbon sequestration potential offive different Bamboo species in mid- Himalaya region on the basis of estimated above-ground biomass and found that all the five species GBH was the major deciding independent variable for biomass estimation. Above ground biomass of *Dendocalamus strictus* was estimated to be 39.1 t ha^{-1} after six year of plantation. *Bambusa bambos* showed maximum biomass (6.21 kg) on a per culm basis among all the five species but culm density was poor and as a result total biomass estimated per hectare was low. Monopodial species *(Phyllostachys nigra)* has more potential to sequester carbon due to high density of culms and high per cent dry matter in the Himalayan region

4. Energy Security

Foronda and Icawalo presented that Bamboo pole can provide Bio-Oil significantly higher than other Biofuel crop as a product of fast pyrolysis with non-condesable gas and bio-char, Bio-oil will act as carbon neutral and can provide energy security.

Conclusion:

Bamboo as a green gold provides all type of security and solution to global challenges. Food security is guaranteed through bamboo-based agro-forestry systems, by maintaining the fertility of adjoining agricultural lands, and as a direct food source. The livelihood security of the people is also taken care through generation of employment in planting, primary and secondary processing, construction, craft and the manufacture of several value added products. All parts of the bamboo plant can be used in rural livelihoods and industry - shoots for food, leaves for fodder and branches for making over a thousand traditional products as well as a host of new generation industrial products. It provides ecological security by conservation of forests through timber substitution, as an efficient carbon sink and as alternative to non-biodegradable and high energy-embodied materials such as plastic and metals.

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Seminar No. 22

Speaker: **Mr. Aadil A Kazi** Reg. No. 04-1319-2012
Degree: Ph.D Forestry (Agroforestry) Course No: FOR-691
Major Adviser: **Dr. D.B. Jadeja** Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel** Date: 29/11/2014

BIRDS, AGRICULTURE AND FORESTRY

There are more than 9946 species of birds found in the world of which 1299 species are reported in India. Among them, more than 170 species are threatened and 15 are in critically endangered position. Recently, 8 new species are added to the 2014 Red List prepared by IUCN. Although less than one per cent of the world's bird species primarily prefer agricultural areas, nearly a third of all bird species occasionally use such habitats and often providing important ecosystem services such as pest control, pollination, seed dispersal and nutrient deposition (Sekercioglu, 2012).The avifauna of India is rich and diversified with nearly 85 % of insectivorous or omnivorous species and feed on insect pests of important agricultural crops (Jadav *et al.* 2013). Besides their useful services in other ecosystems, the birds help agro-ecosystem immensely. By a rough estimation 75 % of birds feed on insects; 250 species control termites; 175 species feed on locust; 50 feed on aphids; more than 50 species control borers, beetles, ticks and mites and 55 species control rats and other vermins (Yahya, 2013). It is important to quantify their role and services rendered in various agricultural crops, forest areas and more importantly in agroforestry systems. The understanding of birds' significant association with agriculture, forestry and agroforestry not only help in framing policies, planning the farm activities and preparing research programmes, but also focus on conservational requirements of some important species which are being threatened day by day. The seminar shall focus on various crucial services, significant or depredatory role, indicative to environmental changes and most importantly their imperceptible role in our day to day lives.

Brief Review of ResearchWork:

Global Ecosystem Services

Wenny *et al.* (2011) studied the need to quantify ecosystem services provided by birds and concluded that more than 50% of bird species are predominantly insectivorous, and nearly 75% eat invertebrates at least occasionally. Nearly 33 % of bird species disperse seeds, primarily through fruit consumption and also through scatter-hoarding of nuts and conifer seed crops.

Sekercioglu (2012) studied functional diversity of birds and their ecosystem services in tropical forests, agroforests and agricultural areas and reported that forest specialist species comprise 53 % of all the bird species found in the tropics, whereas 14 %of tropical species are agroTorest species and 3 % are agricultural specialists. Bird families and genera exhibit similar percentages. Forest is the first habitat choice of 897 agroforest species, whereas 150 agroforest species prefer woodlands, 97 species favour shrub/scrublands and 16 species favour open agricultural areas. Analyses of the distributions of bird species show that agricultural species have bigger ranges and are more widespread than forest or agroforesty species, which do not differ significantly from each other. The global populatlon size differences likely play an important role in determining the proportions of each group that are extinct, threatened, or near threatened with extinction.

Effect of Functional Extinction

Sekercioglu (2011) reported that functional extinctions of bird pollinators cause plant declines. Functional extinction of the birds limited the pollination of the shrub *Rhobdothomnus solandri*, reduced seed production by 84% and reduced number of juvenile plants produced per adult by 55% in the North Island of New Zealand.

Population Dynamics

Mundkur and Nagy (2012) studied the distribution, status and population trends of 2,304 populations of 871 species of waterbird from 32 families and found that under the IUCN Red List criteria, 79 % of all waterbird species considered to be Extinct, Extinct in the Wild, Critically Endangered, Endangered or Vulnerable, belong to

six families. Of these, 28 % of them are Rallidae, followed by Anatidae (19 %), Scolopacidae (8 %), Ardeidae (7 %) and Laridae, Phalacrocoracidae and Gruidae each contribute 6% to the total number of globally threatened water bird species.

Nameer (2014) studied the waterbird at the Kole wetlands of Thrissur, Kerela and found that it supports 243 species of which 130 (53.50 %) resident, 89 (36.63 %) long distant migratory birds and 24 (9.87 %) are vagrants. He also studied the population status of various species of bird families of Kole from 1992 to 2013 and observed the increase/decrease in population of birds of various species.

Insectivore in Agriculture

Narayana *et al.* (2011) worked on avian diversity in selected croplands of Nalgoda district, Andhra Pradesh and found 87 resident and 9migratory bird species. The density of birds were Paddy-139/ha; Cotton-105/ha; Castor-114/ha; Red gram-121/ha; Fruit garden-ll0/ha and Open grassland-111/ha. The related maximum bird density was in Dec 2010 (148/ha) and minimum in Jan 2011 (28/ha). There were statistical differences in bird density among the areas and months ($p<0.05$), but not the habitat.

Jadav *et al.* (2013) recorded 14 bird species from cabbage field feeding insects from the crop. Red-wattled lapwing (25.2 %) was most abundant followed by Yellow wagtail (23 %), Common swallow (12.8 %) and Common myna (10.6 %), whereas the most frequently observed species was Red-wattled lapwing (26.1 %) followed by Common myna (14.5%) and Common swallow (10.1 %). Count of *Lipaphis erysimi* was significantly higher in unsprayed fields (organic plot) (27.22 ± 46.44 aphids/plant, n = 114) compared to pesticide sprayed fields (9.15 ± 7.76 aphids/plant, n = 60). Due to higher infestation of cabbage aphids, average of bird number was also higher in unsprayed fields (9.75 ± 11.63, n = 21) compared to sprayed fields (4 ± 2.17, n = 53). Amongst 14 bird species, 9 (64.29 %) were insectivorous and 5 (35.71 %) were omnivorous. All the birds were confirmed feeding on cabbage aphids.

Kumari and Subramanya (2013) studied on impact of Plain prinia predation on *Helicoverpa armigera* in Ragi *Eleusine coracana* ecosystem and concluded that Plain prinia started building nest only after the crop completed its vegetative phase and reached 50 % earhead emergence, and continued till the mature crop was harvested. Nine insect species were brought to the nests, of which 97 % were pest species and out of them 76.92 % was larva form of *Helicoverpa.* It was found that the impact of 0.81 % of the field population of *Helicoverpa* being consumed by 29 breeding pairs of Plain prinia.

Depredation in Agriculture

Borad *et al.* (2001) studied the damage potential of Indian sarus crane in paddy crop agroecosystem in the Kheda district, Gujarat and revealed that grain loss from the standing crop was always negligible. Maximum weight loss was 0.9 % while average grain loss was minimal (0.03 %). Loss due to trampling of panicles ranged from 0.1 to 7.1 %. In four fields, the trampling area, where all panicles were damaged ranged from 17.2 to 240 m^2. Three out of four such fields had a nest in close vicinity. Thus mechanical damage to the plant was more serious than damage to the grains. Overall yield loss was ranging from 6.1 to 13.6 %. In all fields, damage to the panicles on the peripheral area rX = 0.6 ± 0.5 S.O)was significantly higher than in the core area rX = 0.1 ± 0.2 S.D).

Kale *et 01.* (2014) studied crop depredation by birds in Pune, Akola and Amravati districts of Maharastra and found that maximum loss was recorded to sorghum by Sparrows, Weaver birds, and Parakeets that accounts to 52%. The minimum damage to wheat was 17% and most of the damage was caused by Crows, Pigeons damaged 42% of the peas (chick peas and pigeon peas) while Sparrows and Weaver birds damaged the groundnut by 26 % in the sampling plots. The maximum damage to the pearl millet and sunflower was caused by Sparrows and Weaver birds mostly in Pune and Amravati. Sorghum damage at interior was more as compared to edges.

Fruglvory in Forestry

Balasubramanian *et al* .(2011) studied on Avian frugivory and seed dispersal of Indian sandalwood *Santalum album* in Tamil Nadu and reported that total 217 birds belonging to 7 species visited *Santalum album* in Anaikatty Hills, TN. Among the various avian families, pycynonotidae (Bulbuls) made the majority of visits (41.01 %) followed by White- headed babbler (17.51 %). In the Panchaimalai Hills, 349 birds belonging to 3 species visited the tree during study period. The Indian grey hornblll's diet comprised a reasonable proportion of *Santalum album* fruits both in breeding season (7 %) and non-breeding season (4 %). Birds that are beneficial to

sandalwood dispersal and regeneration were Koel, Common myna, Brahminy starling, Brown-headed barbet, White-headed babbler and Indian grey hornbill.

Sinu *et al.*(2012) studied frugivorous bird diversity and their post-feeding behavior in fruiting *Syzygium cumin;* in fragmented forests of central Western Ghats, India and concluded that Red-whiskered bulbul made an average of 5.27 ± 1.54 visits per hour, which was significantly higher than other four bird species. It is likely to consume an average of 124.39 ± 50.09 fruits/h that was significantly higher than the estimated fruit consumption of Blossom headed parakeet (56.15 ± 7.16), an Oriental white-eye (61.19 ± 25.23) and a Whitecheeked barbet (65.96 ± 18.83). Frequent visitation bouts to and fro between the nest and fruiting trees, the number of fruits consumed/visitation bout and the time spent on the fruiting tree, confirmed the Red-whiskered bulbul as an important dispersal agent of S.*cumini,* which visited the tree in a large flock. The post-feeding behavior of a frugivorous bird influences seed-dispersal mechanism in *S.cumini.*

David *et al.* (2015) studied on frugivory and seed dispersal by birds and mammals in the coastal tropical dry evergreen forests of southern India and recorded 34 bird species from 17 families as frugivores. Among these 8 are major frugivores and 24 are minor frugivores. Fruit colour was dominated by red (25.8 %) and yellow (17.4 %). Most fruits (74.3 %) were berries and drupes. 80 % of plant species are zoochoric and birds solely disperse 20 species (21 %) in tropical dry evergreen forests.

Insectivore in Forestry and Agroforestry

Nemana *et al.* (2013) studied the avifauna of *Acacia ouricutlformis* plantations with emphasis to various age classes in the Agasthyamalai Biosphere Reserve, Kerala and revealed that number of bird species in various age class of plantations varied from 22 (Age class 5) to 29 (Age class 4) and from 33.78 ± 3.28 (Age class 3) to 45 ± 2.59 (Age class 6), respectively. Indian jungle crow accounted for the highest abundance (13.44 %) followed by White-cheeked barbet (9.94 %). The species diversity was highest in age class 6 (3.134) followed by 4 (2.919) and lowest in 5 (2.623). The bird community in A. *auriculiformis* was dominated by insectivores (38 %) followed by omnivores (26 %).

Mass et *al.* (2013) studied role of birds in increasing crop yield in tropical agroforestry landscapes of cacao-legume in Napu Vally, Indonesia. The absence of birds and bats in the full exclosure ($P = 0.004$) and night exclosure ($P = 0.032$), but not in the day exclosure, caused a significant decrease of crop yield compared to the control treatment ($P < 0.05$). The number of harvested cacao fruits was significantly reduced in all experimental treatments, compared to the mean productivity in the control treatment. Day and night exclosures of birds and bats In tropical cacao agroforestry did not only increase the abundance of phytophagous insects, ants and spiders, but also caused an economically important reduction in crop yield (31 % or 730 USD per ha and year), consistently across gradients of shade cover and distance to primary forest.

Mandan *et al.* (2014) found 2493 individual birds belonged to 71 species of 31 families in paddy based agroforestry near Jalgaon, Maharastra. They found that bird species richness ($31 < 43 < 57$) ana abundance ($480 < 785 < 1228$) increased from zero tree density class to high tree density class. Among species, 21 were omnivorous; 21 jnsectivorous; 12 granivorous; 15 carnivorous and 2 nectarivorous, 36 bird species were categorized to be beneficial (i.e. insectivorous and carnivorous) and were found to be abundant in plots with trees. The tree density was found to have a high degree of influence in attracting more birds to paddy fields in terms of species and individuals.

Climate Change

Sekercioglu *et al.* (2008) studied climate change, elevational range shifts and bird extinctions and concluded that elevatlonal range was strongly correlated with the percentage of species at risk of extinction. He predicted that a species whose current elevational range was 1000 m has an 18.6 % probability of being at risk (threatened or near threatened). With a lapse rate of 5.00 C/ km, If that species shifted its lower limit up by 560 m to compensate for an increase in surface temperature of 2.80 C (2.8/5.0 km shift) but was unable to go any higher because there was no habitat available, its elevational range would shrink. The consequent reduction in its elevational range to 440 m would mean that this species would have a 37.5 % probability of being threatened or near threatened.

Acharya and Chettri (2012) studied effect of climate change on birds of Sikkim and found that due to climate change birds were affected because of shift in altitudinal ranges, change in breeding season and breeding failure. Blood pheasant was reported to occur as low as 1500 m and normally between 2600 m to 4500 m but this

species above 3300 m displaying huge shift in lower elevatlonal Ilmlts. The breeding activities such as habitat selection, nest building and even laying of eggs and emergence of hatchlings of Ashy drongo, Black bulbul, Chestnut-crowned laughingthrush, Grey-backed shrike, White-capped redstart and White-collared blackbird were supposedly delayed in response to climate change.

Conclusion:

Studies show that birds do provide biological control services in farmlands and forests nevertheless many bird species act as a pest and are detrimental to agriculture and/or agroforestry. Birds have found to be one of the most diverse groups of ecosystem service providers. Given the ongoing declines in avian functional groups, there is a pressing need to compare their ecological functions in agriculture, forestry and agroforestry to understand how these functions translate to ecosystem services. All India Network Project (AINP) on Agricultural Ornithology by Indian Council of Agricultural Research (lcAR) has been working on understanding birds' role in agriculture, although there is a need for detailed studies focused on agroforestry system specific and bird species specific research to explore the science of bird-plant association further. The AINP on agricultural ornithology needs to be expanded for various geographic region wise studies. Conservation of threatened species is another prime concern in the climate change era and needs to be given due priority seeing as loss of one flagship species of bird before stipulated natural timing cause major repercussions in ecology.

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Seminar No. 23

Speaker: **Mr. Rajveer Singh Chauhan**	Reg. No. 04-1320-2012
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. D.B. Jadeja**	Venue: Conference Hall
Minor Adviser: **Dr. S.K. Jha**	Date: 29/11/2014

EXOTIC TREES IN AGROFORESTRY

Over the time various woody components have been integrated and tested for their potential to satisfy the multifarious needs in different land use systems in India. Agroforestry is one of the land use systems, which holds the promise to address production and protection services. This land use system is being advocated to narrow down the gap of demand and supply of various products (biomass, paper and pulp, fuel wood, fodder etc) on one hand and services on the other. Potential of this practice have been tested through locally available trees as well as introduced ones so called exotics. An exotic is a plant, which is grown outside the limits of its natural range. These exotics are introduced at different times depending on the needs and sometimes policies foster to do so. The main aim of deployment of several exotics has been, to supplement indigenous resources of wood based raw material; afforest barren land/wasteland; offer other environmental services at faster rates and for specific purpose which cannot be fulfilled by native trees. Of many, Eucalypts, Poplars, Casuarinas, Subabool and some Wattles gained much popularity due to their higher productivity, high economic returns and multi-purpose values etc.

Brief Review of Research Work

Exotics in industrial Agroforestry

Lal *et al.* (2006) mentioned that 2070, 285, 2045, 316, 526 and 288 are some good performing clones of *Eucalyptus* in Punjab. Luna *et al.* (2011) reported that WSL-39,Udai, WSL-32,S7C8 are productive clones of poplar in Punjab.

Vijaykumar *et al.* (2011) mentioned that H-4, H-IO, HD-20, HD-16 are good performing clones of *Acacia* hybrid in terms of productivity in Karnataka.

Kulkarni and Venkatesh (2008) mentioned that S-14, S-24, S-22 and S~10 are good performing verities of Subabool and 50, 32, 28, 49 are productive clones of *Casuarina* in Andhra Pradesh.

Exotics in biomass production

Madhusudan *et a1.* (2011) studied the biomass of20 year old MPTs grown on farmland of NAU. They revealed that mean tree aboveground biomass and stand biomass per hectare was highest in *Albizia* (339.16 kg/tree and 379.86 Mg/ha) which was at par with *Casuarina* (331.81 kg/tree and 371.70 Mg/ha) followed by *Eucalyptus* while mll111nUI11 aboveground biomass was recorded in *Grnelina arborea.*

Singh and Gill (2014) concluded that dry biomass was highest in Poplar (167t/ha) followed by *Eucalyptus* (145 t/ha) and lowest was recorded in *Toona ciliata* (60 t/ha) at 7 year of age under agri-silvicultural system in Punjab.

Exotics in fuelwood production

Shiva and Bartwal (2008) compared the calorific value of different fuelwood species. *Albizia lebbek* recorded highest fuelwood value (5200 Kcal/kg) followed by *Prosopis juliflora* (5000 Kcal/kg) and *C. equisetifolia (4950*Kcal/kg).

Kataki and Konwar (2002) worked out Fuelwood Yalue Index (FYI) for some indigenous and exotic fuelwood species. FYI was recorded higher in *P. juliflora* (2100) followed by *Acacia nilotica* (2089) and *A. auriculiformis* (1851).

Exotics in fodder

Singh *et al.* (2009) concluded that *Leucaena leucocephala, Melia azedarach* and *Morus alba* have high nutritional potential for ruminant feeding so may be employed for fodder.

Ramana *et al.* (2000) concluded that *Lleucocephala, A.nilotica* and *Anogeisus pendula* have greatest potential in agroforestry in terms of nutritive value of pruned foliage. So, they can be employed for development of protein banks.

Exotics in soil amelioration

Singh and Singh (1993) studied the arnel iorating effect of different species on alkali soil. Final pH was found lowest (8.3 from 1003) and organic carbon accumulation highest (0.58 from 0.12%) under *Prosopis julijlora* after 20 years of plantation.

Roy *et al.* (2008) studied the population dynamics of meso- fauna under indigenous and exotic tree based silvipastoral system. They found maximum population of *Collembola* and *Mites* under *Acacia tortilis(39.55* x 102 and 1.73m^2) as compared to *Hardwickia binata* based silvi-pastoral system.

Kurnari (2008) observed highest survival rate and LD 50 value in *Casuarina* (20 dSm-l) followed by *Prosopis julijlora, Melia azederach* and *Terminalia arjuna* (16 dSm^{-1}) So they may be tolerant to salinity stress and can be employed in salinity prone area for amelioration ..

Exotics in biodrainage

Ram *et al.* (2008) reported that ground water table beneath *Eucalyptus* plantation was lower as compared to adjacent field. The average draw during April 2005 to April 2008 was 85 cm, up to distance of 66 cm from strip. Roy Chaudhary *et al.(2011*I) reported that ground water table declined at Baghadi site under *Casuarina* plantation from -127 cm to 152.33 cm within 2 years.

Exotics in phytoremediation

Mukhopadhyay *et al.* (2013) analyzed the soil sample of six common species from reclaimed coal mine and derived Reclaimed Mine Soil Index (RMSI) . Based on RMSI they interpreted that species having high RMSI (>0.05) like *Cassia siamea, Dalbergia.sissoo* and medium RMSI (3.00-4.90) like *L.leucocephala* could be recommended for reclamation of overburdened coal mines.

Exotics in carbon sequestration

Chauhan *et al.* (2009) studied the carbon sequestration potential of different indigenous and exotic agroforestry tree species and revealed that *Populus* spp. stored maximum carbon (10.74t/ha) followed by *E.tereticornis* (9.35 t/ha) as compared to other indigenous species.

Kaul *et al.* (2010) studied the carbon sequestration rate of four species using CO2 FIX model. They concluded that mean annual carbon sequestration rate was higher in fast growing Poplar(8 Mg *C/ha/yr)* and *Eucalyptus* (6 Mg *C/ha/yr)* than slow growing Sal(l Mg C/ha/yr) and Teak(2 Mg *C/ha/yr).*

Exotics as shade tree in Coffee Plantation

Patil (2005) studied the growth and yield performance of Coffee under shade of Silver oak and natural shade of Karanja. He concluded that growth and yield performance of coffee was superior under the shade of Silver oak as compared to natural shade of Karanja.

Constraints:

Allelopathy Srinivasan *et al.(* 1990) reported allelopathic effect of *Acacia* spp. and Subabool on agricultural crops. *Similarly,* Chellarnuthu *et al.* (1997), Singh (1996) and Jadhav and Gaynar (1995) reported allelopathic effect of *Eucalyptus. Populus* and *Casuarina respectively* on agricultural crops.

Depletion of resources; Calder (1997), Devi (1983) and Jhorar *et al.* (2008) reported that *Eucalyptus* pull excess water from the ground.

Invasiveness: According to "Country report on invasive species in India" published by APFISN, *Acacia mearnsii, P. juliflora* and *L. leucocephala* are imposing threat for ecosystem by their invasive nature.

Conclusion:

Exotic trees have proved their potential over indigenous in multi-functionary agroforestry *viz.* productivity, biomass production, biodrainage, carbon sequestration, and soil amelioration etc. in some cases they may proved harmful for ecosystem by the way of incompatibility with agricultural crops and invasiveness. So before introduction of exotics in agroforestry, careful evaluation is highly required.

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Seminar No.24

Speaker: **Mr. Aadil A Kazi**	Reg. No. 04-1319-2012
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. D.B. Jadeja**	Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel**	Date: 30/05/2015

AGRICULTURE, TOURISM AND FORESTRY

Tourism today is one of the largest global industries and a major engine for economic growth and employment generation. International tourist arrivals have grown steadily from 25 million in 1950 to over 1.1 billion in 2014. At present, 1 in every 11 people worldwide is employed by the tourism sector, with the industry generating US$ 7.6 trillion or 10% of the global GDP in 2014 (WTTC, 2015). In India beginning with the turn-around in 2002, Foreign Tourist Arrivals (FTA) have steadily grown from 2.38 million in 2002 to 7.70 million in 2014 accounting for 0.68% of global international tourist arrivals. In terms of its share of the international tourism receipts India earned US$ 19657 million (Rs. 120,083 crore) or 1.58% in 2014. Tourism activity provides 277 million jobs globally, and directly accounting for 23 million jobs or 5.5% of total employment in India (WTTC, 2014). This number

swells to 36.6 million or 8.7% of the total jobs when the indirect jobs created by the sector are also included. The total contribution of Travel & Tourism to GDP in India is at INR 7,642.5 billion or 6.7% of GDP in 2014. This is expected to rise by 7.3% per annum to INR 16,587 billion in 2025, accounting for 7.6% of GDP, and generating 45.5 million jobs (9% of the nation's total workforce). The total share of agriculture & allied sectors (Including agriculture, livestock, forestry, fishery and sub sectors) in GDP is 13.9 % during 2013-14. Agriculture and forest related activities can positively be coupled with tourism activity and through Agrotourism and Ecotourism the income of farmers and local people can be raised. India being unique place having ecological, cultural and wildlife diversity has great potential in tourism in these areas.

Brief Review of Research Work:

Budiasa and Ambarawati (2014) studied community based agrotourism as an innovative integrated farming system development model towards sustainable agriculture and tourism in bali and showed that village ecotourism network generated annual profit of USD 3,505.87 from total revenue of USD 23,367.50.

Ghotbinejad and Barghi (2014) studied role of tourism and agroecotourism attractions in rural development in Brazak, Kashan, Iran. The plan of tourism in villages have been described and evaluated carefully by the S.W.O.T model.

Ummiroh and Hardiyani (2013) studied agroecotourism management through cooperative based coffee plantation commodity to increase welfare of coffee farmer and formed agroecotourism cooperative model in which the government has role as regulation maker to bridge agroecotourism cooperative with other stakeholders like Coffee Exporter, Association of Tourism Entrepreneur, and Research Institution. In this model all of stakeholders get benefit. Coffee exporter has coffee supplier that can fulfill export market standard, because there is continuous research in agroecotourism cooperative that is supported by research institution (Coffee Research Center). On other side, research institution can get the facility for research.

Songkhla and Somboonsuke (2013) studied interactions between agrotourism and local agricultural resources management in Chang klang District, Thailand and found that agrotourism activity is directly associated with existing agricultural resources use within farm. They explored that agrotourism had improved local agricultural resources use in terms of conservation of agricultural resources, agricultural extension and value-addition of agricultural resources. At the same time, such use had become the potential in agrotourism marketing. Explaining the form of agrotourism activity generates the interaction between agrotourism promotion and agricultural resources.

Ghosh and Datta (2012) studied on coastal tourism and beach sustainability in Kovalam, Kerala and found that all the beaches of Kovalam had obtained more or less higher scores in case of aesthetic quality. Guest House beach obtained highest score (4 - 4.2) due to its privacy and well maintained international ambiance. Most beaches were rated as average (2-3) in overall cleanliness. It was inferred that most of the beaches in Kovalam reached higher satisfaction levels in case of water quality, litter disposal and recycling of waste materials. The analysis also revealed the fact that the lack of proper development strategy and unplanned growth often hindered the long-term efforts to sustain tourism. A low and insignificant correlation ($r = 0.355$) had been obtained for this beach. On the other hand Light House beach showed progressively poor trend in beach management and consequently its tourism generating potential had also reduced year by year. A very high value of correlation coefficient ($r = 0.865$) was obtained pointing to the ever increasing problems of beach erosion, dumping of litters and absence of pollution combat strategies. Samudra ($r = 0.803$) and Kovalam ($r = 0.663$) beaches had also exhibited similar trends.

Raut and Bhakay (2012) studied problems and solutions of wine tourism in Maharashtra and showed that the combined wine consumption in Asia (excluding Japan) is about US$7 billion, and represents merely 7% of the worldwide consumption value, which is equivalent to 13% of the combined European consumption and 40% of that of the United States. They have developed wine tourism model and destination life cycle for Maharashtra.

Zeppel (2012) published research note on climate change and tourism in the Great Barrier Reef Marine Park, Australia. Climate change seen as the main environmental threat to the Great Barrier Reef (41%), along with cathment runoff (34%) and reduced water quality (26%). Other specific threats were tourism damage (17%), corai bleaching (12%), coastal development (11%), and crown of thorns starfish (10%). The survey also revealed that future climate change actions of GBR tourism operators were Eco Certification (37%), bleach watch monitoring (34%), climate action certification (27%), green purchasing (23%), offsetting emissions (21%), marketing climate actions (20%), switching to alternative fuels (17%), measuring carbon footprint (16%), and building climate change adaptation into their business plan (16%). Barriers to reef tourism operators implementing more climate change actions were cost (50%), lack of time (28%), and not enough information (24%).

Kumbhar (2012) studied on tourists expectations regarding agrotourism at Ratnagiri and Sindhudurg District, Maharashtra and indicated that typically rural food, chance to be involved in the farm, entertainment value, quality water, peace and quiet, on-site restrooms, clean and green environment, countryside accommodations, educational value attractive location and interaction with service providers are scored 4.00 to 4.53. Quality food, purchasing opportunities, security & trust, interpersonal congruency, participate in local festivals, interact with rural people, continuing of relationship with farmer, and primary health care facilities scored from 3.45 to 3.98. Convenient location, adequate parking and luxurious accommodations are less important factors which score ranging from 2.22 to 2.38.

Dixit and Narula (2010) studied ecotourism in Madhav National Park, MP and found that 40% of visitors originated locally - from other Indian states (17%), 42% of visitors stayed less than 24 hours in the national park. The activities participated in by more than half of the respondents all related to the enjoyment of nature, and included hiking (76%), sightseeing (72%), observing wildlife (66%), relaxing (61%) and photography (61%). Over two-thirds of respondents indicated that being close to nature (78%), encountering wildlife (72%), learning about nature (70%) and viewing the scenery (71%) were very/extremely important. Vegetation damage along walk-trails, and hiking away from walk-trails, were also noted as current impacts by over 20% of the sample. In contrast to these biophysical impacts, only 5% of respondents perceived visitor numbers - a social impact - to be a current concern.

Kumar (2009) studied the impact assessment of ecotourism on visitors and villagers in Satpuda National Park, MP and found that roughly 50% of the sampled visitors desire to visit the park again. The impact of ecotourism on food intake by villagers has been the most visible (Mean 0.58) because of the enhancement in the income.

Rathore *et al.* (2008) studied on promotion of ecotourism to conserve wildlife corridors as a strategy for the Kanha-Pench landscape in India and articulated Community Based Ecotourism (CBET) approach to development of ecotourism in the Kanha-Pench corridor area with a focus on rural livelihoods and landscape conservation.

Seema *et al.* (2006) prepared white paper on ecotourism policy and proposed institutional mechanisms and linkages. The models of ecotourism assessment and monitoring were devised under ecological, socio-cultural and economic categories.

Conclusion:

Overall review showed that ecotourism in a sustainable manner can potentially enhance the livelihood of local people, particularly those living in and around ecologically fragile areas and, as a result, also provide local people an incentive to conserve these areas. Developing countries like India should offer additional source of income to the farmers so as to prop up the economy of family. In today's Indian scenario when farmers are worried due to crop failure and meager remuneration from the forest related works, the ecotourism models can help them build a sustaining supportive income. The conservation in protected areas has also been a burning issue and ecotourism can help promote conservation if taken systematically. Certification of ecotourism modules and standardization of education and facilities being provided in each ecotourism site are the requirement in Indian

ecotourism sites. The systematic and scientific approach towards our natural assests can bring radical change in the lives of rural communities.

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Seminar No.25

Speaker: **Mr. Manas Ranjan Nayak**	Reg. No. 1030313002
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. D.B. Jadeja**	Venue: Conference Hall
Minor Adviser: **Dr. D.P. Patel**	Date: 03/05/2015

RECLAMATION OF DEGRADED LANDS THROUGH AGROFORESTRY INTERVENTIONS

The degraded lands are the lands which are presently degraded and lying unutilized except current fallows due to various constraints. To check the trend of decreasing land for agriculture, degrading of soil and water resources, increasing pollution hazards, threats to the environment and ecosystem, new approaches in farming systems are required to meet food, fodder, fibre, firewood and timber for the 21st century. The primary cause of land degradation in India is the demographic pressure, leading to loss of vegetation cover due to deforestation. Harvesting of timber, collecting of firewood, overgrazing, shifting cultivation, encroachment of forest areas and unscientific mining for minerals are some of the reasons for deforestation and desertification. Besides these, ignorance of proper soil and water conservation measures, non-judicious use of agrochemicals,'

faulty irrigation and water management practices, discharge of industrial effluents, sewage/sludge, build up salt affected soils, water logging etc.are also responsible for land degradation to a considerable extent. Other causes of land degradation are diversion of arable land to other uses i. e. industrial development, urbanization, road construction etc.

About 2 billion ha area in the world is affected by various forms of human-induced land degradation (Oldeman, 1991).Out of 329 million ha geographical area of India, about 187.8 million ha (57.1 %) suffer from different limitations expressed to varying degrees and getting further degraded through natural and/or anthropogenic process. The extent of land degradation in the country has been assessed by different organization which indicates the degradation of land is not constant as it is varying with time (Mishra and Rath, 2013). To reclaim or ameliorate the degraded lands from further degradation and to improve the soil properties, different methods are practiced, out of which agroforestry is one. Sustainable development, management and biological reclamation of these lands through agroforestry interventions not only meet the multiple needs for food, fodder, fuelwood, fiber, fertilizer, etc. but also economic and environmental security is guaranteed for safe and protected habitat for humans and other living organisms by harmonization of proper land use. Agroforestry reclaims the degraded lands by minimizing concentration of salts, soil erosion and prevents the further deterioration of physico-chemical properties of cultivated soils, which improve the soil fertility as well as productivity.

Brief review of research work:

Saline soils

Dagar (2013) reported that important species of trees, shrubs, grasses and forbs for saline soils which are categorized into different tolerant groups *viz.* high tolerant (EC of 30-40 dSm^{-1}, tolerant (EC of 20-30 dS^{m-l}) and moderately tolerant (EC of 10-20 dSm^{-1}).

Singh (2011) reported that Populus based agroforestry system reduces maximum pH where as Acacia based system increases maximum organic carbon (%) and available N (kg/ ha) as compared to other systems in the saline soil.

Yadav *et al.* (2009) studied the bioameliorative effects of trees in saline soil and found that highest available N, P and K status of soil *i.e.* 560.2 kg ha-I, 87.8 kg ha' and 77.2 kg ha' respectively under *Gliricidia maculata* where as more OC (g/ kg) of 14.4 under *Dalbergia sissoo.*

Basavaraja *et al.* (2007) found that planting *Prosopis juliflora* significantly decreases pH and ECe. The ESP reduction was found to be 71.96 % (0-15 cm) and 51.88 % (60-90 cm). The CEC increased to an extent of 11.19 % (0-15 cm) and 72.73 % (60-90 cm), where as organic carbon increased. from 0.78 % to 1.61 % at surface (0-15 cm), while at deeper depth (60-90 cm) it increased from 0.44 % to 0.92 %. The available N increased from 220.00 kg N ha^{-1} to 362.50 kg N ha^{-1}, available P_20_5 and K_20 increased from 20.00 kg/ha to 26.25 kg/ha and 167.00 kg/ha to 299.75 kg/ha at surface (0-15 cm), respectively over ten years of *Prosopis juliflora* plantation as compared to barren land.

Alkali soils

Dagar (2013) reported that the relative tolerance for pH of important species of fuelwood, fodder, timber and fruit tree species for alkali soils which are categorized into different groups based on intensity of soil sodicity like more than 10, 9.6-10,9.1-9.5 and 8.2-9.0.

Roy (2003) reported that there was improvement in alkali soil condition as decrease in pH and EC with increase in soilorganic carbon, N, P, K in varying depths of 0-15 cm and 15-30 cm after the 9 years of *P.juliflora* plantation. Also studied the effects of *P. juiiflora* plantation after 8 years on OC status of sodic soils in 4 villages of Haryana and found that the soil OC increased in all the villages compared to initial value.

Singh (2011) reported that there is decrease in pH and EC whereas increase in organic carbon and available N in varying depths after 74 months of *Prosopis juiiflora –Leptochloa fusca* silvipastoral system in alkali soil.

Yadav *et al.* (2009) concluded that there is improvement in alkali soil condition under all the adopted land use systems as evidenced by decrease in pH and EC ($dS\ m^{-1}$) and increase in OC (%), available N, P, K (kg/ha). Again they reported decrease in pH and improvement in organic carbon (%), total N (%) and available N (kg/ha) after 30 months in *Sesbania sesban* planted at varying spacing.

Singh *et al.* (2014) found maximum Ca2+ + Mg2+ (3.5 me L-I) and K+ (0.18 me L-I) of 0.18 and minimum Na + (6.96 me LI), Cl (5 me L-I) and ESP (30) in the treatment T, *(P. juliflora + L. fusca)* in the soil

depth of 0-15 cm. There is reduction in soil pH and EC in all the treatments, where as increase in OC content was recorded in T, *(P.juliflora + L. fusca)* and *T6(Acacia nilotica + Leptochloa fuscai.* Similar trend were recorded for available N, P, K (kg/ ha).

Ahmed *et at.* (2012) reported that soil bulk density, pH, moisture content and organic matter are higher in 4 x 4m spacing than 4 x 8 m. Similarly all the soil parameters, except the hydraulic conductivity, are decreasing when the soil depth is increasing.

Yadav *et al.* (2009) found that soil pH and ESP reduced considerably under *Azadirachta indica* and *Pongamia pinnata* plantation. The soil organic carbon increased slightly under *Azadirachta indica* (2 - 4 times) in comparison to *Pongamia pinnata* (1.7 times), however, both the species enriched the soil organic carbon particularly in surface layer of 0-15 ern depth.

Biswas and Biswas (2014) concluded that *Prosopis juliflora* added more soil organic matter (0.58%) and reduced pH from 10.3 to 8.03 as compared to other trees after 20 years of plantation. They also found that the ECe and ESP considerably reduced and OC (%) increased over control after the 7 years of plantation.

Singh *et al.* (2008) concluded that *P. juliflora* reduces maximum pH, EC (dSm^{-1}) and ESP of 9.5, 0.30 and 51 to initial value of 10.6,1.43 and 85-92 respectively and increased the maximum OC (g/kg) from initial of 0.8 to 4.3 .

Mine spoils

Chaturvedi *et al.* (2014) reported some suitable plant species like *Eucalyptus species, Acacia species, Dalbergia sissoo etc.* for revegetaion in different categories of mine spoils area.

Dadhwal and Juyal (2007) reported that after the intervention of agroforestry, the pH of the spoil came down from 8.1 to 7.4, organic carbon and total N (%) increased from 0.13 to 0.45 % and 0.01 to 0.05 % respectively where as CaCa3 (%) decreased from 54.6 to 29.5 and the bulk density from 1.63 to 1.45 Mg/ m^3.

Dutta and Agrawal (2002) found that the soil organic carbon content was maximum under *Acacia auriculiformis (0.60%)* and minimum in *Cassia siamia* (0.47 %). The total N (%) content in soil around different plantations were 0.047 to 0.062 % and total P content varied among different plant species with maximum concentration in *Casuarina equisetifolia* (0.017). All the soil parameters are higher in plantation condition than the fresh mine spoil.

Eroded lands

Gupta *et al.,* (2006) reported that the dispersion ratio and erosion ratio in both the surface and subsurface soil decreases with the increase in tree age of agroforestry system. However, the average value of WSA (Water Stable Aggregates) > 0.5 mm is remarkably higher (19.8 and 14.9 times) in surface and subsurface soils ofagroforestry than the non-agroforestry condition. They also found that the dispersion ratio as well as erosion ratio is less in agroforestry of different textured soils compared to nonagroforestry. Again within agroforestry the loamy sand soil has maximum dispersion ratio (3.4) and erosion ratio (11.6) in the surface soils.

Roy (2003) studied the ameliorative effects of alley cropping on runoff and soil erosion under maize-cowpea rotation and reported that the runoff (% of rainfall) and soil erosion (t ha/yr) is lowest under Leucaena of 4 m and 2 m spacing which is 0.7 and 0.-10 respectively.

Singh (2011) found that soil storage is maximum and soil loss (mg/ ha) is minimum in ridge-and-furrow (RFS) planting system which is in the trend of increasing and decreasing respectively from 1982 to 1984.

Conclusion:

Agroforestry is a dynamic land management system; ameliorates or reclaims the degraded lands in various ways. Review showed that trees in the different agroforestry systems ameliorate the saline, alkali, mine spoils and degraded lands. Trees particularly tolerant of high salt concentration like *P. juliflora, A. niiotica, A. indica, etc.* not only.reclaim the salt affected soils by reducing soil pH, EC, ESP but also increasing the soil fertility by improving sac and available nutrient status of soils. Similarly tree species like *A. auriculiformis,* C. *equisetifolia etc.* reclaim the mine spoils degraded lands. The eroded lands are reclaimed through the agroforestry practices as the run-off, soil erosion, dispersion ratio and erosion ratio are less as compared to nonagroforestry practices. Hence practices of agroforestry correctly reclaim the degraded lands.

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Seminar No.26

Speaker: **Mr. Rajveer Singh Chauhan**	Reg. No. 04-1320-2012
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. D.B. Jadeja**	Venue: Conference Hall
Minor Adviser: **Dr. S.K. Jha**	Date: 30/05/2015

AGROFORESTRY FOR BIOFUELS

India is the ninth largest economy in the world, driven by a real GDP growth of 8.7% in the last 5 years. To deliver a sustained growth rate of 9 %, and to meet the energy needs of the country, India needs to increase primary energy supply by 3 to 4 times. Presently, India is the fourth largest consumer of crude oil and natural gas in the world and out of the total consumption of petroleum products, more than 75% requirement is met through imports. Maximum (37%) share of foreign currency reserve goes to pay the import bill of crude oil. Transportation sector is the major consumer of petroleum energy (70%) and contributer in air pollution. Biofuels are being promoted widely as a solution to rising fuel prices, growing energy demands, and to cut green-house gases but supply of raw material is still a question. To achieve 20% mandatory blending targets by 2017 as advocated in National Biofuel Policy of 2009, there will be a need of nearly 19 Mt of biodesiel, for which, nearly 20 M ha area would be required under biofuel plantations against the 0.5 M ha at present (Raju *et* al.,2012). Looking to the future demand of biofuel (increasing 7.5% annually) and wasteland availability (43.15M ha) in India, agroforestry may be a potential way to integrate perennial woody biofuel crops with traditional agriculture crops to satisfy energy demands without sacrificing food production.

Brief review of research work:

Component interaction studies

Suvera *et al.* (2015) intercropped four *Ocimum* species under *Pongamia pinnata* based silvi-medicinal system. Significantly higher average oil yield of *Ocimum* spp. was recorded under silvi-medicinal systems (50.75 kg/ha) as compared to sole cropping (45.41kg/ha).

Khan and Hasan (2015) evaluated the performance of Bitter gourd *(Momordica charantia)* as arable crop with Karanja *(Pongamia pinnata* L.) trees in an agroforestry system. Under the system, highest fresh yield (1.64 t/ ha)was obtained when Bitter gourd were grown more than 100 cm distance away from the tree base, which was statistically similar to the yield of the sole crop.

Vishwanath *et al* (2014) evaluated the yield of Soybean as intercrop under seven biofuel tree species. Under the agroforestry system, yield of Soybean was maximum under *Madhuca latifolia* (1577 kg/ha) which was *at par* with *Calophyllum inophyllum* (1541 kg/ha).

Banarjee *et al.* (2013) compared the yield of Pigeon pea grown under two TBOs namely, Neem *(Azadirachta indica)* and Karanj *(Pongamia pinnata)* as intercrop and as sole crop systems. Yield of Pigeon pea were higher under Karanja plantation (1.51 t ha ^{1}) as compared to Neem (1.40 t ha^{-1}).

Ahir (2010) recorded minimum reduction in the yield of Cowpea var. Guj-1 (5.12%) as compared to sole crop, when grown under *Jatropha* based agroforestry system.

Anon. (2010) tried seven intercrops for higher productivity in *Pongamia* based agroforestry system. Results showed that Cowpea and Groundnut were least affected by perennial tree as compared to other crops. In another study, Tulsi was recommended as suitable crop under *Simarouba* based agroforestry system.

Singh *et al.* (2007) found that Dh 86 (1.85 t ha^{-i}) and ICGV 93468 (1.84 t/ha) varieties of Groundnut produced significantly higher pod yield during summer season under *Jatropha* based agroforestry system.

Divya *et al.* (2006) observed significantly minimum reduction in yield of Cowpea at different spacing of *Jatropha* based agroforestry system as compared to sole crop system. Minimum reduction in yield were observed at wider spacing (4x3m) under *Jatropha* based agroforestry system.

Anon. (2006) reported minimum reduction in the yield of Cowpea (2%) under *Simarouba* based agri-silvi system as compared to sole crop.

Gill *et al.* (2003) grown Wheat cv. WH 147 under 12 important MPTs. Grain yield of Wheat was maximum in 2nd and 3rd year under the canopy of *Madhuca latifolia* .

Kumar (1999) reported that Varuna, Rajat and Kranti varieties of Mustard are suitable for intercropping with minimum reduction in the seed yield (12.0, 12.08 and 12.78% respectively) under Neem based agroforestry system as compared to sole crop.

Jaimini (1995) studied the effect of trees on yield of agricultural crops in Neem based agroforestry system. The per cent decrease in grain yield under agri-silvi system was from 35.85% in Green gram to 19.75 % in Cowpea as compared to sole. However, there was no decrease in the production of Clusterbean under agri-silvi system.

Puri and Bangarwa (1992) conducted a study in the semi-arid regions of Haryana, to see the effect of *Azadirachta indica, Prosopis cineraria, Dalbergia sissoo* and *Acacia nilotica* on the yield of irrigated Wheat crop. Results indicated that *A. indica* and *P. cineraria* did not show any significant difference in Wheat yield under the agroforestry system. While, *D. sissoo* and *A. nilotica* showed a reduction in Wheat yield.

Component & system management trials:

Haldankar and Somvanshi (2015) studied the effect of foliar application of nutrients after 30 days of fruit set on harvesting and yield of Kokum *(Garcinia indica* C.). Among all the treatments studied, spray of KNO_3 (3.0%) at 30 days after fruit set and MKP (0.5%) at 50 days after fruit set was the best which pre-poned the harvesting period by 39.5 days and maximised the fruit yield (84.17 kg/plant) of Kokum tree.

Gayakvad *et al.* (2014) undertaken a study to determine the effect of foliar application on seed yield of *Jatropha* . Significantly higher seed yield (355.53 kg/ha) was obtained when plants were sprayed with GA_3 @ 50ppm.

Kumar (2011) recorded significantly higher fruit yield (968 g/plant) of *Jatropha curcas,* When plants are applied irrigation at 83.33 CPE and 60g N+120g **P_20_5+60** g K_20 per plant.

Chamar (2008) evaluated the effect of pruning and fertilizer on yield of Jatropha curcas. Significantly maximumseed yield (47.85 g/plant) was recorded when trees are pruned at 60 cm from the ground and applied fertilizer (NPK) at the rate of 100:100:100g per plant.

Economics of the system:

Anon. (2014) recorded maximum yield and gross return (9244 Rs./ha) when chickpea was grown under *Simarouba* + Guava based agri horti system.

Solanki *et al.* (2014) recorded higher BC ratio (1: 1 .67 and 1:1.71) of the system, when Basil was grown under Sapota-*Jatropha* based three tier agroforestry system.

Prathyusa and Hemlatha (2013) found maximum BC ratio (2.88) when sweet corn was intercropped under *Pongamia* + Maize agri-silvi system.

Conclusion:

Agroforestry may be viable option to establish sustainable production system for biofuel supplies in sufficient volume that meet current and future demands.For the sustained supply of biofuels and food on the same land synergy and economic returns are to be considered.Right policy decision by government and improved planting material /agronomic practices developed by the scientists will be a key factor for successful biofuel programme in India.

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Seminar No.27

Speaker: **Mr. Jayesh Pathak** Reg. No. 04-1318-2012
Degree: M.Sc. Forestry (Agroforestry) Course No: FOR-692
Major Adviser: **Dr. D.B. Jadeja** Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel** Date: 30/05/2015

FODDER TREES IN AGROFORESTRY-IMPORTANCE AND MANAGEMENT

Tree fodders are widely available and traditionally used by livestock farmers throughout the tropical developing world including India. An important feature of fodder trees is that they are underused in feeding systems, especially with ruminant animals. These feeds are valuable supplements, provide considerable variety to grass/crop residues based diets, and have considerable potential in supporting economic animal production. The importance of tree fodders become even more critical in the context of increasing animal populations and decreasing available grazing lands. The growth in Indian livestock sector is demand-driven, comprehensive and pro-poor. Incidence of rural poverty is less in states where livestock accounts for a sizeable share of agricultural income as well as employment. India's livestock sector is one of the largest in the world. Livestock population is around 529.70 million and is expected to grow at the rate of 0.55percentage in the coming years (Ghosh *et al.* 2014). There is tremendous pressure of livestock on available total feed and fodder, as land available for fodder production has been decreasing. At present, the country faces a net deficit of 35.6 percentage green fodder, 10.95 percentage dry crop residues and 44percentage concentrate feed ingredients (Ghosh *et al.* 2014). There is urgent need to meet the demand of increasing number of livestock and also enhance their productivity for which availability of feed resources have to be increased.

Brief review of research work:

Chatterjee *et al.* (2012) studied the nutritional value of various fodder trees/ shrubs which grow naturally in different agro-climatic regions of the country and it was observed that the range of variation was 7.0-33.4, 0.76-11.1, 7.749.8, 18.7125-69.8, 2.6- 22.9, 0.10-4.8 and 0.10-1.0 percentage, in crude protein, ether extract, crude fiber, nitrogen free extract, total ash, calcium and phosphorus, respectively. Tree leaves of some species such as *Grewia, Leucaena, Morus, Sesbania and Melia azadarach* were found to contain more than 20 percentage crude protein. While more than 15 percentage crude protein was observed in a number of fodder trees.

Inam-ur-Rahim *et al.* (2011) studied nutritional aspects of the fodder tree leaves and shrubs available in Pakistan and concluded that the overall Dry Matter of all trees and shrubs vary from 21.7 to 38.6percentage *(Melia azadarach* has the lowest and *Quercus dilatata* has the highest Dry Matter content). Among shrubs, the DM content vary from 22.2percentage for *Dodonaea viscosa* to 38.1 percentage for *Indigojera gerardiana* and *Impatiens bicolor.* The more DM, the less amount of foliage required to fill the rumen of the recipient animal.

Kumar (2003) studied the antinutritional factors (ANF) in fodder tree leaves and reviewed thoroughly that the ANFs which have been implicated in limiting the utilization of tree forages include non-protein amino acids, glycosides, phytohemagglutinins, polyphenols, alkaloids, triterpenes and oxalic acid etc. ANF diminish not only animal productivity but may also cause toxicity during periods of scarcity or confinement when the feed rich in these substances is consumed by animals in large quantities. He also studied the Anti nutritional effects of tannins in some fodder tree leaves/pods and reviewed that the tannins have a more profound digestibility-reducing effect which latter may cause varied toxic manifestations due to hydrolysis in rumen.

Premaratne (1993) studied effect of fodder supplementation on the DM intake and *in vivo* digestibility and weight gain in sheep and reported that field supplements of *Gliricidia sepiwn, Tithonia diversifolia* and *Leucanea leucocephela* have a significant effect on voluntary intake and digestability of rice straw, which in turn resulted in weight gain of sheep. He also studied effect of leucaena supplementation on live weight gains and results indicate a significant effect of supplementation on live weight gain of calves and goats.

Singh *et al.* (1990) studied the comparative performance of lambs and kids under silvopasture and natural grassland and reported that lambs and kids under silvipasture agroforestry systems showed significant

live-weight gains. The kids gained 40.8 g/head/day in silvipasture system compare to 17.2g/head/day in natural grassland during 4-5 months. While, the lamb gained 58.4 g/head/day in silvipasture system compare to 33.9 g/head/day in natural grassland during 4-5 months.

Dicko and Sangare, (1981) studied the estimated quantities (in tons DM) and values (in US dollars) of browse and crop residues in 23 km^2, which was presented for sale at Niono market, Mali. He found that the highest weight (458 tons) was recorded for *Pterocarpus lucens.* However, the leaves of shrubs and trees had an estimated value of 10734 US dollars.

Youkhana and Idol (2008) studied effects of *Leucaena leucocephala* and *Robinia pseudoacacia* on soil physical properties and chemical properties and found that the physical properties of the soil were also significantly different under *Leucanea leucocephela* and *Robinia pseudoacacia.* Soil bulk densities were lower under both species (810 and 816 kg mt^3 for *L. leucocephela* and *R. pseudoacacia* respectively) at the end of the experiment compared with the value prior to planting (901 kg m^{-3}). Soil porosity was slightly higher under *L. leucocephela* and *R. pseudoacacia,* and infiltration rates were significantly greater than at the beginning of the experiment. Results of soil particle size distribution (texture) showed no differences in all fields while Soil chemical and nutrient properties were also significantly improved in the presence of the tree species. Soil pH increased significantly under *L. leucocephala* and *R. pseudoacacia* (5.58 and 6.20, respectively compared with 4.92 prior to planting). Total soil organic matter and nitrogen under the tree species also increased significantly over the course of the experiment. Available potassium in the soil increased from an average of two ppm at the beginning of the experiment to 375 ppm under *L. leucocephala* and 304 ppm under ;. *R. pseudoacacia.* Available phosphorus, however, was not significantly different between the various treatments. Surprisingly, available ammonium and nitrate did not differ significantly between the soils although nitrogen availability in all soils was quite high, especially for ammonium.

Rao (2007) studied biomass of macrofaunal groups under different land-use systems at Muguga, Kenya. Observations made at Muguga, Kenya under natural forest, continuously cropped maize, one-year-old *Sesbania* fallow, and grass fellow indicated that *Sesbania* fallows restored the soil biological activity to the same level as in natural forest and was several-fold higher than in the cropped fields or grass fallows.

Palm (1995) reviewed percent of added N released from leaves of agroforestry trees during eight weeks of incubation from various studies and reported that *Gliricidia sepium* consistently released a higher percentage, 30- 70 percentage, of its N compared to other materials. *Leucaena leucocephala* leaves, with N percentage greater than 3.5 in all but one study, generally released less than 25percentage of its initial N. *Senna siamea,* a non N-fixing legume, released an intermediate percentage, 10-40percentage, of the N added, In all cases *Senna, siamea* showed initial immobilization that lasted up to six weeks before net mineralization occurred. Some of the studies have also shown temporary immobilization from other legumes. *Calliandra calothrysus* and *Inga edulis* released less than 20percentage of the applied N. In contrast, *Dactyladenia barteri*, a nonlegume, showed net immobilization throughout the incubation. He also reviewed the percentage N mineralized, percentage recovery of total N added, percent recovery of the N mineralized, percentage remaining in undecomposed plant material, and the percentage of that is unaccounted for following the additions of the leaves of several agroforestry trees to crops and reported that the amount of N added from the leaves or pruning of agroforestry species taken up by the crop is quite low. Recovery values are generally less than 20 percentage and more frequently closer to 10 percentage .The materials that released a higher percentage of initial N, such as *Gliricidia sepium* and *Sesbania sesban*, had higher percent recoveries than materials that released a smaller percent of N, such as *Calliandra calothrysus.*

Kiwia *et al.* (2009) studied added nitrogen from improved fallow after four harvests (2000-2004) of different species in western Kenya and the highest additions of nitrogen was observed from *Calliandra calothyrsus.* Farmers in western Kenya have reported maize yield increases of up, to 200 percentages from improved fallow.

Kwesiga *et* al.(1999) reported a substantial increase in maize yield i.e. 5.4 t/ha after two years of an improved fallow system in Malawi, where maize grown after *Sesbania sesban* fallow,which increased maize yields as compared to plots fertilized with inorganic nitrogen i.e. 4.0t/ha.

Mombasa (1994) summarises four years data on Leucaena intercropped with Maize and found that total dry matter yields were increased from 16.4 t/ha when Napier grass was grown alone to 29 t/ha for Napier plus

Leucaena plus manure slurry. The effects of nitrogen source (fertilizer or *Clitoris ternalea)* were also demonstrated. It is important to note the contribution of slurry, a potential water pollutant.

Ruaysoongnern (1989) studied the concentration of various elements in the young leaves of nodulated *Leucaena leucocephala* and recorded critical nutrient values in index leaves of young seedlings and some typical nutrient concentrations in young leaves of vigorously growing Leucaena plants. Concentrations substantially lower then these values can be regarded as deficient.

Aref and EI-Juhany (1999) studied dry matter production (kg ha^{-1}) by *Leucaena leucocephala* and *Albizia lebbeck* trees after 24 month of irrigation at 160 mm (Well Water supply, WWS) and at 500 mm (Low water supply, LWS) and reported that dry matter partitioning to tree parts also differed significantly between the two species. *Leucanea leucocephela* trees had greater leaf and stem weight ratio (P0.0001) and lower branch and root weight ratio (P0.0001) than A. *lebbeck.* in both situation i.e. Well Water supply, (WWS) and Low Water supply, (LWS).

Youkhana and Idol (2008) also studied the effects of pollarding height and frequency on *Leucanea leucocephela* and *R.pseudoacacia* growth responses. He found that both pollarding height and frequency had significant effects on the biomass production and nutrient concentration of *Leucanea leucocephela* and *R. pseudoacacia,* but their interactions were not significant. For *Leucanea leucocephala,* pollarding twice (every 3 months) at 15 cm yielded the greatest growth response and tissue N and P contents. For *R. pseudoacacia,* pollarding once after 6 months at a height of 45 cm yielded the highest biomass production and tissue N and P contents.

Singh and Bishnoi (2014) studied the sun dried leaf fodder yield (kg) per tree of *Prosopis cineraria* with different lopping intensities and found that the fodder yield was generally more from the trees that are lopped annually as compared to those lopped once in two years or once in three years. It was also observed that, the yield of forage increases as the tree girth increases. The study indicates that the *P. cineraria* trees should be lopped annually to gain higher benefits in the form of fodder.

Stur *et al.* (1994) studied the effect of cutting interval on edible fraction and stem yield of *Leucanea leucocephela* and found that the most frequent cutting treatments studied (40-day and 60-day intervals, respectively) gave the best yields of *Leucanea leucocephela* leaf.

Pezo *et al.* (1990) studied on the productivity of *Gliricidia sepium* or *Erythrina berteroana* as live fences, different pruning intervals were evaluated at four sites in the lowland humid tropics and they found that the total biomass yield increased as the pruning interval was delayed, but the proportion of edible biomass declined with age. Also, tree survival was negatively affected by frequent pruning. This study suggested to maintain the productivity at an acceptable rate in such systems, the pruning interval has to be at least 4 months.

Singh *et al.* (1999) recommended that *Prosopis cineraria* can be planted at 8 x 6 in spacing (208 trees /ha) upto 12 years age without significant reduction in crop yield. *Colophospermum mopane* is the best for rehabilitation of degraded land under direct seed sowing after ploughing. *Hardwickia binata* is suitable species to enhance production per unit area i.e. crop, fodder and fuel wood in arid and semi arid region whereas the indirect benefits are soil improvement, increase in carbon stock and reduced soil losses. *Acacia nilotica* enhance yield during drought and increase system productivity. But it will be more appropriate to plant the species as boundary plantation or erecting shelterbelt. Though *Acacia tortilis* enhance total production of the system during drought but it will be more appropriate to plant the species on boundary or erecting shelterbelt. It is good species for agroforestry and necessary to motivate farmers that at least 20-25percentage of the fields should be kept aside for traditional tree and pasture species to get more forage and other products. *Ailanthus excelsa* is a good species for boundary plantation as well as commercial farm forestry in sandy soil of arid and semi arid region.

Nair *et al. (1994)* reported a list of recommended fodder bank species and their respective ecological zones which shows some tree species with potential to be used as a fodder bank. It can be seen that fodder bank is practiced more frequently in humid and sub-humid regions, it is due in part to the high moisture requirement by the trees in association with crops or grass.

Conclusion:

It is now well recognized that to meet the fodder requirements of livestock, the fodder production should be improved by augmenting top feed tree species. These tree species besides producing fodder, yield

sufficient fuel wood and timbers. Tree leaves are being increasingly used to provide fodder for livestock, as they have a number of unique characteristics which make them attractive for both smallholder and large scale livestock enterprises. On an average, tree leaf fodder production of 0.2 to 2.0 ton /ha/year is obtained by pruning up-to 50percentage height of the trees every year from the various agroforestry systems under different agro-climatic zones. These tree leaves are rich in quality nutrients like protein, minerals and vitamins and used as valuable supplements to provide considerable variety to grass/crop residues based diets of livestock. Tree lopping studies and understanding their growth and regrowth pattern is essential, to advise the higher leaf fodder production. Multipurpose trees contribute in many ways to soil management and conservation, and provide very valuable nutrients to animals. However, some multipurpose trees contain anti-nutritional factors which can be detrimental to animal production or could be harnessed to nutritional advantage. In the dry season however, the quantity and quality of forage greatly decreases and is generally low in nutritional value. Livestock sustained on such diets often lose weight and productivity. To avoid this problem farmers must provide their animals with quality feeds to augment dry season forages. A practical option for this situation is to establish fodder banks.

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ACADEMIC YEAR : 2105-16

Seminar No. 28

Speaker: **Mr. Maulik H. Amlani**	Reg. No. 2030314004
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. M. B. Tandel**	Venue: Conference Hall
Minor Adviser: **Dr. V. M. Prajapati**	Date: 19/09/2015

VARIABILITY IN BAMBOOS

Bamboo, the fastest growing woody grass on the earth, has attracted great deal of attention all across the globe due to its usefulness in enhancing productivity and providing environment and livelihood security through multifarious uses. There are more than 1500 recorded uses of bamboo. Bamboo stands occupy an area of 36 million hectares worldwide which is equivalent to 3.2 percent of the total forest area in the world. According to the INBAR global thematic study, over 63 percentages of bamboo resources are privately owned and the remaining 36 percentage bamboo plantations are owned by Governmental entities. In comparison 80 percentage of all world forests are public owned. India has largest bamboo forest area in the world with 11.40 million hectares or 16.8% of the total forest area (Anonymous, 2007). There are different reports on the number of genera and species of bamboo found in India. As per the ..test compilation, 18 genera and 128 species have been reported. Of the total species found in India, about 20 are commercially used (Tewari, 1992; Seethalakshmi and Kumar, 1998). The annual consumption of bamboo in India is estimated to be about 4 metric tonnes out of which only 1 % comes from plantation and rest 99 % is obtained from forests. The current demand of bamboo is 26.69 million tonnes against supply of 13.47 million tonnes in the country. This multipurpose species has enormous potential which has only been partly harnessed. Once cultivated, returns from bamboo are recurrent on annual basis after 5-6 years without much recurring investment in plantation thus making it commercially viable option for large scale cultivation.

Brief review of research work :

Nath *et al.* (2007) studied morphological variation of *Schizostachyum dullooa* and found that average Culm height (6.63m), Culm DBH (2.99 cm), internode length (19.6 cm) and culm wall thickness (0.42 cm).

Shalini *et al.* (2013) studied morphological observation of different genotypes of bamboo and observed that *Bambusa tulda* and *Bambusa balcoa* were very similar to each other for all four characters. While, *Guadia angustifolia* showed very different type's characters in all four traits but it showed highest number of new culms as compared to others.

Nath *et al*. (2008) studied the colour differentiate at different age classes of culms in *Bambusa cacharensis, B. vulgaris,* and *B. balcooa.*

Kumar *et al.* (2005) revealed that mineral elements concentration of tissue types decreased in the order Thorns + Leaves > Live culms > Dead Culms. However, highest accumulation was observed in live culms followed by Thorns + Leaves

Bhandari *et al*. (2013) stated that there was adequate amount of variability present for most of the characters in different species of bamboo and selection can be effectively practiced for desirable types as per the breeding objectives. The magnitude of heritable variation and more particularly, its genetic components are the most important aspects of breeding.

Kumar (2009) revealed that *Dendrocalamus strictus* have highest ether Extract (0.82 %), Minerals (1.14 %), Phosphorus (58.13 mg/100g), Iron (2.917 mg/100g), Hydrocyanic acid (0.13 %) and Carbohydrates (9.94 %) and lowest Moisture (85.98 %). However, calcium (180.69 mg/100g) was noted higher in *Bambusa polymorpha* and Protein (3.29 %) and Niacin (6.70 %) in *Melocanna baccifera.*

Paul (2010) concluded that *Dendrocalamus dikumensis, B. tulda and B. nutans* have good nutrient quality when integrated with fodder plants.

Nongdam and Tikendra (2014) studied the comparison of nutritive values of shoots of edible bamboos with some of the popularly consumed vegetables in different parts of the world and found that *Bambusa tulda* and *Dendrocalamus hamiltonii* have higher amount of Amino acids, Protein, Fats, Fibre, Potassium, Iron and

Zinc as compared to popularly consumed vegetables. They also stated that raw shoots of *Dendrocalamus aspen, Dendrocalamus strictus,* and *Bambusa tulda* have comparatively higher nutrient composition as compared to boiled and fermented bamboo shoots.

Ghosh *et al.* (2012) studied AFLP analysis using six pairs of primer combinations of the eighteen landraces of bamboo comprising of nine species under four genera revealed 1620 alleles, out of which 1229 alleles appeared polymorphic and 391 alleles appeared monomorphic.

Goyal and Sen (2014) recorded 19 scorable bands by the various restriction digestion enzymes ranging in between 200-1986 bp. Of the 19 cuts 9 were polymorphic. The percentage of polymorphism ranged from 20% to 70%. The overall polymorphism was found to be 47.37%.

Loh *et al.* (2000) revealed that similarity index between *B. lako* and *G. atroviolacea* was the highest, suggesting that *B. lako* is more appropriately included within the genus *Gigantochloa* rather than the genus *Bambusa.* The two *Dendrocalamus* species examined were very different with *D. brandisii* clustering within one of the *Bambusa* clusi.crs and *D. giganteus* appearing as a very distant species.

Suson *et al.* (2015) found that dendrogram pattern produced two separate major clusters with *B. balcooa* and *Dendrocalamus hamiltonii* grouped in one cluster, while *Melocanna baccifera, B. mizorameana* and *D. giganteus* constituting another cluster.

Cluster analysis clearly showed two major clusters belonging to 10 species of bamboo. Major Cluster 1 was further subdivided into three minor clusters. The species of *Bambusa tulda* and *Bambusa balcoa* were the most closely related and formed the third minor cluster along with *Bambusa nutans* and *Dendrocalamus strictus.* The variety *Guadia ngustifolia* was very distinct and showed as an out group in the dendrogram that was single species in cluster B (Shalini *et al.*, 2013).

Nath *et al.* (2015) suggested that present synthesis of bamboo can generate tradable amount of carbon under CDM and REDD schemes. Biomass carbon storage and sequestration rate of 30-121 Mg /ha and 6-13 Mg/ ha/ yr, respectively in woody bamboos are comparable with agroforestry and forest ecosystems.

Conclusion :

The different species of Bamboo has morphological, genetical, nutritional and molecular variations. The *Bambusa tulda* and *Bambusa balcoa* were very similar to each other for height of mature culms, internode distance, number of new culms and circumference while, *Guadia angustifolia* showed high magnitude of variation in all four traits. The *Dendrocalamus strictus, D. dikumensis, B. tulda , B. nutans* and *D. hamiltonii* have good nutritional value as compared to vegetables. The raw shoots of *Dendrocalamus asper, Dendrocalamus strictus,* and *Bambusa tulda* have comparatively higher nutrient composition as compared to boiled and fermented bamboo shoots. Moreover, the different species of Bamboo has also variability at molecular level. The two *Dendrocalamus* species viz., *D. brandisii* and *D. giganteus* showed higher variation at molecular level and appeared in two different clusters.

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Seminar No. 29

Speaker: **Mr. Bhanderi Bhavin N.**	Reg. No. 2030314002
Degree: M.Sc. Forestry (Watershed Management)	Course No: FOR-591
Major Adviser: **Dr. P. K. Shrivastava**	Venue: Conference Hall
Minor Adviser: **Dr. Dileshwar Nayak**	Date: 19/09/2015

EFFICACY OF POND IN FOREST WATERSHED

Geographical area of India is about 329 M. ha which is crisscrossed by a large number of small and big rivers. The country is divided into 29 States and 7 Union Territories, with a population of 1,276.267 Million (2015 census). Rivers, streams ponds and other water bodies are the major source of livelihood for large population which depends upon agriculture. Other than rivers and canals, total water bodies cover an area of about 7 M. ha. Among the remaining forms of the inland water resources, tanks and ponds have maximum area (2.9 M. ha.) followed by reservoirs (2.1 M. ha.). Most of the area under tanks and ponds lies in Southern States of Andhra Pradesh, Karnataka and Tamil Nadu. These states along with West Bengal, Rajasthan and Uttar Pradesh, account for 62 percent of total area under tanks and ponds in the country. Orissa ranks first as regards the total area of brackish water followed by Gujarat, Kerala and West Bengal. The total area of inland water resources is, thus, unevenly distributed over the country with five states namely Orissa, Andhra Pradesh, Gujarat, Karnataka and West Bengal accounting for more than half of the country's inland water bodies.

Forest and water

India has approximately 22 % forest area with all types of wild life and tribal villagers living in these forests. As per the land use classification forests are in the land having more than 8 % slope, which indicates water bodies for survival of all biodiversity is from streams, ponds, rivulets and artesian wells. Further, water flow in small streams and rivulets is seasonal in these forest areas and like in urban areas availability of bore well or canal water supply for drinking and irrigation purpose is limited to forest villages. Further, due to large scale deforestation most of the natural water bodies have got filled up by sedimentations and there is hardly any documentation of the efficacy of forest ponds or water bodies in forest areas that is essentially needed in planning budgetary allocation by governments.

The links between forests and fresh water are inextricable; they play a dominant role in providing drinking water to all life forms. Forest vegetation obstructs surface runoff, leaf litter act as sponge that helps in infiltration of the water and tree roots transmit water to underground water aquifers. The forest cover reduces the maintenance costs of water treatment by providing quality clean drinking water to

millions of people. Forest catchments supply a high proportion of the water for domestic, agricultural, industrial and ecological needs in both upstream and downstream areas of any water bodies. There is an urgent need for a better understanding of the interactions between forests/trees and water, for raising awareness and capacity building in forest hydrology, and for embedding this knowledge and the research findings in I 'cies. To sustain wild life and tribal people in forest areas revival of existing ponds or natural water sources is the need orthe hour which needs understanding of intricacies of watershed hydrology. The layman understanding could begin with knowing different type of pond that are present or could be planned, they may be classified as Surface pond, Off stream pond, Barrage pond, Check dams, Plastic pond, Mechanical fed pond and Concrete pump fed pond. Such small or big ponds could be designed by a forester by evaluating the drinking water demands of the forested watershed, irrigation needs, specific uses (aquaculture etc.) and the water available during monsoon.

Review of research work:

Siddique *et al.* (2012) studied soil parameters of ponds of different age, to establish the relationship between different aged ponds with different bottom soil parameters. Three groups of ponds (1-5 years, 6-10 years and above 10 years) were analyzed. No significant variation were found among different aged group ponds with respect to soil pH but the amount of organic matter, organic carbon, silt and clay significantly increased with the increase of pond age.

Rouf and Kazi (2014) studied the Green Economic Development by leasing Ponds in Bangladesh Government Jurisdiction to Local Community from Gratneen Fisheries and Livestock Foundation (GMPF) which is involved in mobilizing people engaged in livestock and fish production, agriculture, horticulture, homestead gardening, social forestation and bio gas plants and other community green income generating economic activities. These ponds helped to bring improvement in quality of life of the poor, in particular poor women. GMPF is managing 1035 public ponds having 2557.3 acres of water bodies and 20 fish seed farms leased for 25 years, these ponds are regular source of income to poor.

Hazra (1998) conducted study on the watershed conservation by the creating a check dam on Kharaiya nala and they found reduced soil erosion from 41t/ha to 1.9t/ha, reduction in runoff from 70% to 22%, rise in water table from 12m to 6m depth, increase in number of wells dug by villagers from 12 to 483, increase in proportion of irrigated land from 9.6% to 69%, over 300 ha of arable wasteland brought into crop production, area sown under kharif and rabi increased by 85% and 233%; cultivation in zaid for first time, Fodder planted on almost 150 ha of field bunds and gully plugs, dry fodder production increased by 235%. and local people found employment as farm labour.

Giri, (2010) from Regional Centre, Central Research Institute, Bhubaneswar motivated farmer (Sri Dehury) to utilize his small unproductive pond for duck rearing with male (14) and female (17) ducks. He reports farmer started receiving duck eggs after six month of establishment and they got 2642 eggs, out of which 2100 eggs were sold in local market at the rate of Rs. 5 /egg. In the first year he had the income Rs 14,000 /- . After this success CARI motivated other 450 farmer and 30 SHG for doing duck rearing in unproductive ponds.

Sankanur *et al.(*2011a) conducted study on soil and moisture conservation (SMC) program in Medak forest division, Andhra Pradesh. They found the result of SMC programme increased the agro forestry crop area, increased wet land and also reported land use change in the area with increased annual production. Further, Sankanur *et .al*.(2011b) conducted another study on soil and moisture conservation program in Mehboobnagar forest division, Andhra Pradesh. Here also, they report that SMC programme increased the agro forestry crop area , increase wet land and also that through SMC programme's people can generate income for livelihood. Similar study was conducted by Sankanur *et .al*.(2012a) in Bijapur forest divisior Andhra Pradesh. In this study they report SMC programme's decreased the ground water depth which helped in--- increasing the number of bore wells to irrigate the agricultural crops. Sankanur *et* al.(2012b) documents that the SMC programme's promoted land use changes with more number of species of grain and fodder crops and tribal farmers could take two or three seasons of crop annually.

Penny Williams et. al. (2003) studied relative biodiversity value of different water body types such as river, stream, ditch and pond biodiversity within an 80 km^2 area of lowland British countryside. The results showed that although all waterbody types contributed to the diversity of macrophytes and macro invertebrates in the region, they differed in relative value. Individual river sites were rich but relatively uniform in their species

composition. Individual ponds varied considerably in species richness, with the richest sites supporting similar numbers of taxa to the best river sections, but the poorest sites amongst the most impoverished for all water body types. At a regional level, they found that ponds contributed most to biodiversity, supporting considerably more species, more unique species and more scarce species than other water body types. They concluded that as a whole, ponds and other small water bodies can contribute significantly to regional biodiversity.

Beat Oertli et. al.(2002) established the relationship between pond area and species by considering size and diversity for 80 ponds in Switzerland, using richness (number of species) and conservation value (score for all species present, according to their degree of rarity) of aquatic plants, molluscs (Gastropoda, Sphaeriidae), Coleoptera, Odonat (adults) and Amphibia. Pond size was found to be important only for Odonata and explained 31% of the variability oktheir species richness. Pond size showed only a feeble relationship with the species richness of all other groups, particularly the Coleoptera and Amphibia. The weakness of this relationship was also indicated by the low z-values obtained (< 0.13). The SLOSS analyses showed that a set of ponds of small size has more species and has a higher conservation value than a single large pond of the same total area. But we also show that large ponds harbour species missing in the smaller ponds. Finally, they concluded that in a global conservation policy (protection, restoration, management), all size ranges of ponds should be promoted.

Surve, et.al. (2014) reported that the total expenses incurred for development of Naysari Agriculture University watersheds was around Rs 46.5 lakh. Uncultivable waste lands in the NAU watershed were used either for water conservation or growing fodder grasses, Jatropa, forest species as per the suitability of land and available water. It was found that for Naysari and its surroundings areas to irrigates around 5 to 8 ha area annually a pond of 1 ha size having a depth of 2.5 m BGL (below ground level) is needed.

Shrivastava, et. al. (2007) reports by harvesting runoff water in a pond, mango and cashew trees survived and also the harvested water was used in irrigating rabi onion in kyari land, in the undulating topography of Agricultural Experiment Station, NAU, Paria.

Conclusion:

Pond in forested watershed could be said to the main life line not only wildlife but also acts as a resting place of wild animals, so pond is responsible for maintaining of whole forest ecosystem. Mainly forest found at high altitude so the forest pond's recharges ground water and decrease depth of water table at lower altitude which could be used by tribal farmers for irrigation, drinking and other domestic purposes. In hilly areas, pond is helpful to the local people for meeting their water demands. It is also an important part for raising forest nurseries, plantation and watershed management. Now a day's forest pond could be a part of ecotourism sites and wildlife photography, thus facilitating employment to the local people.

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Seminar No. 30

Speaker: **Mr. Bhuva Dhaval C.**	Reg. No. 2030314003
Degree: M.Sc. Forestry (Forest Genetic Resources)	Course No: FOR-591
Major Adviser: **Dr. Dr. R.P. Gunaga**	Venue: Conference Hall
Minor Adviser: **Dr. Manmohan J. Dobriyal**	Date: 15/12/2015

POLLINATION MECHANISM IN TROPICAL FOREST SPECIES

Tropical forests are the richest global forests representing maximum species composition, density, abundance, genetic diversity, biomass and carbon sequestration potential. Pollination is one of the mechanisms to enrich the tropical forests (TFs) across the country. Furthermore, pollination is considered as one of the components while evaluation of forest ecosystem services. The process of pollination is fundamental to the long-term sustainability of a plant. Most of the tropical tree species are pollinated by medium-sized to large bees, followed by moths, small diverse insects and small bees (Bawa, 1990). Species pollinated by various groups of pollinators recorded to be distributed non-randomly. The greatest diversity of pollination systems in TFs was recorded in the subcanopy, where hummingbird and sphingid moth are recorded as primary pollinated species. In case of top canopy, monotonous pollination system was recorded where bees and small diverse insects are primary pollinators. It is known that wind pollination is rare, but not absent in many tropical forests. It is estimated that approximately 98 to 99% of all the flowering plant species in tropical lowland rain forests are pollinated by animals (zoophilous; Bawa, 1990). Biotic pollen vectors range all the way from one to two millimeter-long fig wasps to flying foxes with a wingspan of two meters (Wiebes, 1979). There are reports on alteration of sexes, andro/gyno dioecy and monecy to crypto dioecy and monoecy, as well as temporal dioecy and monoecy (Borges *et al.,* 1997; Sunnichan *et al.,* 2003 & Dunthorn, 2004). Interestingly, some trees showed mixed pollinators *(Butea monosperma)* and few of them showed specific pollinators as the case in Fig and Tetu (Tandon *et al.,* 2003 & Vikas *et al.,* 2009). In the study, different types of pollination and its mechanism for promoting self and cross pollination in plants are described. In the presentation, different

mechanisms of pollination in tropical forest species with some of the case studies have been addressed and salient features are given below.

Review of Research Work

Diallo *et al* (2008) studied the breeding system and pollination biology in tamarind. Result showed that all three modes of pollination are found to be functional, where more fruit set and more number of loges per pod were recorded in open pollinated, followed by cross pollinated condition. However, they were least in self-pollinated condition. Observation of the germination and the pollen tubes growth under above mentioned pollination modes showed that the tamarind is an incompatible species partially.

Borges *et al.* (1997) studied the alternations of sexes in *Bridelia retusa* and they reported that, even though it is a monoecious plant, *B. retusa* showed temporal dioecious condition, where 10/13, 1/13, 1/13, 1/13 of individuals recorded female to male, male to female, female-male-female and all male sexual conditions, respectively during 4 different periods in study site-I. In another site (II), the similar observation have been recorded along with female-male-female- male (2/9) and male-female-male-female (1/9) sexual conditions in the same phonological period indicating temporal dioecy.

Nagarajan *et al.* (2006) undertaken phonological aspects and control pollination in different seed sources of *Casuarina equisetifolia.* They have recorded dioecious breeding type in all the seed sources, except Danger provenance from Australia, where they have shown predominantly monoecious type. Male inflorescences are significantly shorter in length in monoecious trees than dioecious male trees. Among five studied clones, about 55-93% of cross-pollinated flowers set fruits and the percentage of seedlings emerging from them varied from 38 to 68%. Self-pollination resulted in 63% seed set of which 37% germinated and developed.

Sunnichan *et al* (2003) examined the floral sexuality and breeding system in 20 trees of *Sterculia urens.* Tree is recorded as andromonoecious and it produced male and bisexual flowers. Trees bearing ID GG 1, GG 5, GG 6 and GG 10 did not bear bisexual flowers in their four years study period. The number of bisexual flowers were least as compared to those of male flowers. The number of male (1198 to 3501) and bisexual flowers (0 to 167) varied not only from tree to tree but also during the flowering period in the same tree. The fruit set under open pollination was very low (0.7 to 3.2%) in the Ghatti population of *S. urens.* Pollination studies showed that pollen grains of bisexual flowers are completely sterile and incapable of siring any seeds. Moreover, anther helps in attracting pollinators. Finally, they opined that this species exhibits cryptic monoecy.

Dunthorn (2004) studied the pollen characters and flower types in eight *Mammea species.* Result showed that pollen from the male flowers is recorded to be aperturate, whereas in bisexual flower, pollen grain showed inaperturate and thus unlikely to be able to germinate. Therefore, *Mammea* also showed cryptic dioecy.

Patel *et al* (1993) described the pollination in monoecious fig species and explained the mutualism between fig-wasp relationships.

Hombe Gowda *et al.* (2002) studied the breeding types in *Nothapodytes nimmoniana,* an important medicinal tree species. They have recorded a wide array of breeding types with male (10%), female (34%), hermaphrodite (12%), monoecious (2%), andromonoecious (30%), gynomonoecious (5%), trimonoecious (7%) at individual level; whereas androdioecious and gynodioecious types at population level. Overall male flowers showed bigger in size, followed by bisexual and it was comparatively smaller in female flowers.

Atluri *et al* (2004) examined control pollination in *Shorea robusta.* Breeding experiments showed high percentage of autogamy (95%), geitonogamy (91%) and xenogamy (90%). However, apomixis was completely absent. Experiment showed a strong protogyny with prolonged stigma receptivity indicating nature of cross pollination and pollen traits showing characteristics of wind pollinated species.

Rangaiah *et al.* (2004) characterized the flowers in relation to pollinators in *Erythrina variegata.* They found that the flowers are bigger and have red corolla and lack odour, moreover stamens and stigma are positioned in such a way that the probing birds contact them with their breast and head. Further, they observed that nectar is copiously produced and well protected in the keel petals and all these conforming the ornithophilous nature of pollination in *E, variegata.*

Vikas *et al.* (2009) studied the control pollination and fruit set in bat pollinated species, *Oroxylum indicum.* Result showed that about 25 % fruit set was recorded in cross pollinated flowers, whereas open

pollinated flowers showed very low fruit set (0.29 to 0.65). However, self-pollination, autogamy and apomixes types of pollination resulted in null fruit set.

Bawa (1990) overviewed the insect pollination in tropical species in which different types of insect that pollinate different plant species are discussed.

Tandon *et al.* (2003) reported the flower visitors, flower handling time and foraging behaviour in *Butea monosperma*. It is recorded that total seven bird species along with three-stripped squirrel and honey bees visited the trees. Among these, purple sunbird and squirrel were found to be effective pollinators. In the control pollination, fruit set was significantly higher (22.51 %) in xenogamy. Whereas, geitonogamy showed the least fruit set of 5.25 %.

Bawa (1990) also summarized the percentage of self compatible species, self-incompatible species and dieocious species in different forests.

Indira and Mohanadas (2002) examined fruit set through different pollination system (self and cross) by control pollination in teak. Per cent fruit set varied among pollination types, where maximum fruit set was recorded in cross pollination as compared to self pollination over a period of time after pollination. Interestingly, 82 to 85 per cent of fruit set was found to be aborted in both pollination types.

Vasudeva *et al* (2001) studied breeding system in *Semecarpus kathalekanensis.* It is reported that species showed various breeding types-male, female and monoecy indicating trioecious condition. They have mentioned about mutualistic relationship of plant pollinator, where butterfly is only observed as pollinating agent.

Conclusion: Study shows that there are great variations in flowering behavior, pollination pattern, ecological plant-pollinator relationship among tropical forest species. It is indicated that pollination study is fundamental importance for ecological and breeding aspects of any tree species that helps in further investigations. Similarly, environmental factors also play an important role in shaping breeding system in many species, example alternation of sex in *Bridelia retusa,* cryptic dioecious and monoecious nature in in *Mammea* and *Sterculia urens,* respectively.

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Seminar No. 31

Speaker: **Mr. Chaudhari Chintankurnar K.**	Reg. No. 2030314003
Degree: M.Sc. Forestry (Forest Biotechnology)	Course No: FOR-591
Major Adviser: **Dr. Dr. S. K. Jha**	Venue: Conference Hall
Minor Adviser: **Dr. R.P.Gunaga**	Date: 19/09/2015

CURRENT STATUS OF APPLICATION OF MOLECULAR MARKER TECHNOLOGY IN TEAK *(Tectona grandis* Linn. F.)

Teak, an important source of tropical timber, grows naturally in forests of India, Myanmar, northern Thailand, Laos and Indonesia. The natural teak forests in India are the largest in the world, occupying an area of 8.9 million ha in central and peninsular region of the country (Tewari, 1992). In India the demand for teak has increased several folds during the last five decades, resulting in extraction of trees from old plantations and from natural forest. Extraction of best teak from forest has resulted in the loss of good genotypes (Katwal, 2003). The availability of information on the genetic variation within populations and the differentiation between populations plays a significant role in the formulation of appropriate management strategies for conservation of genetic resources (Milligan *et al.*, 1994). The molecular data of markers can be of great use in defining the best methods of genetic conservation and insuring tracking of future evolution of variability. Molecular marker can be utilized in several other ways including marker aided selection and QTL mapping, which can be immensely helpful in teak improvement programme. They can also be very effective to combat illegal logging or to certify wood provenance. On the other hand, it is necessary to note that the molecular data should be completed by phenotypic and ecological data. Various sources of information will be necessary to protect and manage the genetic variability of teak in its natural area. Molecular markers have been proved valuable tools in the characterization and evaluation of genetic diversity within and between species and populations.

Brief Review of Research Work:

Murukan and Murugan (2015) analyzed morphometric and genetic polymorphism among the teak selected from six different localities of Kerala, India. Morphometric analysis resulted variations among the accessions. They used RAPD for polymorphism detections *in* genomic DNA. Dendrogram clustered the clones into two major clades, the first clad further bifurcated into two having taxa from Munnar, Palakkad and ldukki. The second clad have taxa from Kochi, Kollam and Thiruvananthapuram, India. There was much similarity between cluster formed from molecular marker and phenotypic data.

Narayanan *et al.* (2007) characterized assorted accessions (plus trees) of Teak at the National Teak Germplasm Bank, Chandrapur, India using RAPD and ISSR markers. RAPD primers amplified more loci than ISSR primers. However, RAPD and ISSR primers amplified 93.2 and 95.9% polymorphic loci respectively.

Ansari *et al.* (2012) conducted genetic diversity and structure analysis of twenty nine populations of Teak collected from central and peninsular India. They extracted genomic DNA from ten randomly selected individuals of each population and amplified using five ISSR primers. The primers showed 100% polymorphism. Nevertheless, the cluster analysis distinguished the drier Teak populations of central India from the moist Teak populations of south India, which was also confirmed by Principle Coordinate Analysis.

Vaisnaw *et al.* (2015) used five amplified fragment length polymorphism (AFLP) primer combinations for analysis of genetic diversity, differentiation, and structure of 96 genotypes of Teak from 10 natural locations in India. The population genetic structure resolved by the neighbour joining tree, principal coordinate analysis, and no-admixture and admixture model Bayesian-based analyses irrefutably revealed two distinct centers of Teak diversity, i.e., central India and peninsular India.

Shrestha *et al.* (2005) investigated patterns of genetic variation within and among nine populations of *T. grandis* from diverse geographical regions in India, Thailand, and Indonesia using amplified fragment length polymorphism (AFLP). Cluster analysis and principal coordinate analysis indicated that Indian

populations are clearly separated from those in Thailand and Indonesia. However, the Berbera population from Orissa near the Indian northeastern coast is an exception, as it seems to have associations with both the Indian and the Thai—Indonesian populations.

Sreekanth *et al.* (2012) investigated the genetic structure within and between nine natural teak growing forests of the Western Ghats of India belonging to the states of Kerala, Karnataka and Tamil Nadu using AFLP markers to provide reasoned scientific management practices and conservation measures. The Southern Western Ghats populations showed higher within population gene diversity. Positive correlation between genetic and geographical distances was observed. PCoA, UPGMA and STRUCTURE analyses revealed the tendency of the individual trees within a population to align together indicating specific identity of each population. In the UPGMA dendrogram, Nilambur population joined separately with a large cluster in which the other Kerala populations and Tamr, Nadu population formed sub clusters indicating a separate identity for Nilambur population among Southern Western Ghats populations.

Fofana *et al.* (2008) reported the use of site-specific recombinase (SSR) technology using microsatellite DNA markers to investigate the level of genetic variability, distribution of genetic variation and genetic relatedness in *Tectona grandis* grown in Cote d'Ivoire. The SSR markers showed a clear differentiation of the populations introduced in Cote d'Ivoire with an Fst = 0.21. The populations coming from the natural area were characterized by three clusters corresponding to South India, North India and Thailand. The study on the origin of African teak was close to North of India.

Fofana *et al.* (2009) used fifteen micro- satellite markers to study the genetic variability and structure of 166 Teak trees distributed over the whole natural area of Teak. Analysis showed that in the Teak natural area there were four main centers of genetic variability. Two clusters were in India (i.e. North India and South India) and could be considered as main centers of genetic diversity in Teak.

Conclusion:

Molecular marker has been successfully utilized in *Tectona grandi.s.* Till now, molecular markers have been applied for plus tree characterization, genetic diversity study, population origin study and population variability study in Teak. Advance uses of markers e.g QTL identification and MAS is lacking since population development is major bottleneck.

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Seminar No.32

Speaker: **Mr. Damor Vipulkumar V.**	Reg. No. 2030314005
Degree: M.Sc. Forestry (Medicinal & Aromatic Plants)	Course No: FOR-591
Major Adviser: **Dr. B.S. Desai**	Venue: Conference Hall
Minor Adviser: **Dr. V.M. Prajapati**	Date: 03/10/2015

STATUS OF ETHNOBOTANICAL STUDIES OF GUJARAT

The term Ethnobotany was first coined by Harshberger (1896). Since then many eminent scientists has defined ethno botany. Schultes (1962), defines it as the study of relationship that exists between people of primitive societies & their surrounding plant environment. According to Krauss (1974), the term Ethno botany is derived from Ethnology which means the study of man & botany. According to Powers (1873:, In : Castteter (1944) cited by Cotton, (1997), the term Ethno botany is derived from the word "Aboriginal Botany", means the study of all forms of vegetation which aborigines used for commodities such as medicine, food, textiles & ornaments. Jain (1981) defined it to be the relationship between human society & plants.

Ethnobotany of Gujarat State:

The first pioneer work on tribal uses was done by eminent botanists Late Shri J. I. Thaker on Barda hills & Kachchh regions. To name few, ethnobotanical work gain momentum by the pioneering works of Late Dr. G. L. Shah, Dr. G. V. Gopal, Dr. B. G. Vashi, Dr. A. S. Reddy & Dr. B. L. Punjani. Looking into the tribal scenario of Gujarat, maximum tribal population is found in the district of Dangs (93.76 %), followed by Dahod & Valsad districts (72.26 % & 54.76 %) resp. Tribal distribution is mainly concentrated in North Eastern region of Gujarat, accounting to 18 % of the state's area (5884 villages), with 26 tribes, spread across 14 Eastern districts, 48 talukas, 15 pockets & 4 clusters. In all, there are 172 publications in Gujarat dealing with various ethnobotanical aspects, few of which are presented here region wise, tribe wise, disease wise, plant group wise etc. Total 1500 ethnobotanical plants are used for various purposes by tribals of Gujarat.

Brief Review of Research Work:

Anonymous (2006), reported that around 450 wild plants are used as for non medicinal uses by tribals of Gujarat. 76 wild plants used as vegetables, 74 as fruits & seeds & 43 used as a fodder plants.

Umadevi & Parabia (2009), analyzed that out of 1200 ethnobotanical plants of Gujarat, around 750 wild plants are used in human Ethno medicines. Maximum, 438 species are used in alimentary canal & digestive problems. This is followed by 334 species in skin diseases & 302 species in gynecological disorders.

Maru & Patel (2012), studied ethno medicinal plants to cure different diseases by tribals of Jhalod taluka in Central Gujarat. They reported that both leaves & bark are used maximum (29 % each) for curing various diseases. Total ethno botanical species recorded was 29.

Patel, *et al*. (2014), worked on Ethnobotany of tribals in Bhiloda region of North Gujarat. Out of all the plant parts used, maximum 28 % of roots are utilized as medicines for curing different diseases.

Anonymous (2012), has given review of ethno medicinal plants used by tribals of Kutch region. They reported the out of 964 plants species; 341 species used in ethno medicinal purpose i.e 35.37 %. Herbs were predominantly used for ethno medicinal purpose accounting to 52.21 %. Plants of family Fabaceae are used maximum i.e. 13.20 %.

Patel *et al*. (2012 a), studied the Ethnobotany of tribals residing at Tapkeshwari Hills in Kutch region. They reported that out of 37 plants enlisted, shrubs were found predominantly used in ethno medicine accounting to 38 %.

Mitaliya (1998), worked on ethno medicinal plants used by tribals of Bhavnagar district. Total of 52 species were recorded. With respect to plant parts used, maximum usage was of leaves (69 %).

Shah, *et al*. (1981), studied the Ethnobotany of overall Saurashtra region. They enlisted 131 plant species of ethnobotanical significance. Out of 131, trees were used maximum (54 species), whereas leaves (25 %) & fruits (22 %) are used maximum as plant parts.

Kumar & Desai (2014), studied the ethnobotanical profile of Dangi Bhagats. They reported total of 121 species, out of which 55 tree species & 42 herbaceous species are used. Leaves & roots are used maximum with 43 % & 22 % respectively.

Reddy (1987), conducted research on Ethno botany of Dharamapur Forests. Total of 167 species were reported, out of which trees & herbs were used maximum (69 & 57 spp. respectively). Bark was used maximum (27 %) for ethno botanical purpose.

Anonymous (2002), studied the Ethnobotany of plants used by the tribals of Ratanmahal WLS. Out of total 70 spp, herbs & climbers are used maximum (30 & 21 spp resp). Leaves & roots are used maximum (57 % & 37 % resp) by tribals of Ratanmahal WLS.

Anonymous (2002), studied the Ethnobotany of plants used by the tribals of Bansda NP. Out of total 100 spp, trees & hers are used maximum (45 & 34 spp resp). Leaves & roots are used maximum (25 % & 18 % resp) by tribals of Bansda NP.

Bedi (1978), conducted research on Ethno botany of specific tribe i.e. Bhils, Dhankas & Naikas in Central Gujarat. He revealed that the out of total 72 ethnobotanical species; herbs were used predominantly accounting to 42.85 %. This was followed by climbers, shrubs & trees i.e. 30 %, 17.14 % & 10 % respectively.

Punjani (2002 a), conducted research on ethno botany of Kathodia tribe in context to Fishing & Hunting devices. Stem bark of *Butea monosperma*, *Balanites aegyptica* & *Holoptelea integrifolia* are used for fish poisons. Strips of *Dendrocalamus strictus* & fibres of Jangli Bhindi (*Abelmoschus manihot*) are used as Fish hunting weapon. Bird hunting devices called as Fenno & it is made from fruit of Ingoriyo & node of Vans. Gofan also used to hunt Birds & it is made out of stem fibre of *Abelmoschus manihot* or root fibres of *Butea monosperma* or long adventitious roots of *Ficus benghalensis.* Panjari is bird catching device & it is prepared from stem of *Nyctanthes arbortristis* or Arni (*Clerodendrum multiflorum*), fibres of *Abelmoschus manihot* & thin strips of *Dendrocalamus strictus*.

Punjani (2006), studied the Ethnobotany of specific tribe – Kathodia of North Gujarat. He reported that out of 35 species; 13 species of herbs were used in ethno medicine. In case of plant parts, leaves & roots were used maximum (24 % each).

Punjani (2002b), also carried out research on ethnobotanical studies on plants used by Dungra bhils & Garasia tribes of Aravalli forests in North Gujarat. He reported total of 216 ethno botanical applications, out of which 131 applications (61%) is used for Medicinal purposes.

Patel, *et al*. (2012 b), conducted research on ethnobotanical plants used by Rabari tribe of Dhinodhar & Tapkeshwari hills in Kutch region. They reported that shrubs were used highest in Dhinodhar & Tapkeshwari hills 13 spp & 14 spp resp.

Punjani (2007), carried out study on Ethnobotany of Maldharis of Gir forests in context to life forms & utility pattern of plant parts. He reported that the out of 27 plant species, 10 herbs were used as ethnobotanical plants. This was followed by trees, climbers & shrubs (8, 7 & 2 spp) resp. With respect to utility pattern of plant parts; 44 % of leaves were used as Ethnomedicines.

Navroja & Kanchna (2012), studied ethnobotanical plants used by Kukna tribe of Waghai. They reported that out of 49 species; 25 species of herbs were used predominantly. In context to plant parts; 33 % leaves are used as medicine, whereas tubers & rhizomes are used least, 4 % & 2% respectively.

Shah & Gopal (1986), carried out study on Ethnobotany of Vasava tribes of Sagbara range. They reported total 22 ethnobotanical plants. Out of which, maximum plants were used to cure Bone fracture, Body pain, Constipation, Gynaecological problems & Stomach pain (2 each). Bark & roots were used maximum (8 diseases & 7 diseases) respectively.

Thakor (2009), studied the Ethnobotany of Varli tribe in Dharampur region. He reported total 42 ethnobotanical plants; out of which 20 trees were used in ethno medicine. This was followed by herbs, shrubs & climbers (11, 6 & 5 spp) respectively. Leaves (25 %) were used maximum as medicines.

Shah & Gopal (1982), studied the Ethnobotany of plants used by Dangi Bhagats. They reported around 146 plants, out of which, 44 % of trees were used as ethnobotanical plants. Herb spp accounts to 40 % of medicines.

Kshirsagar, *et al*. (2003), carried out research on ethno botany of Machhi & Koli tribe of Coastal South Gujarat. Out of 55 spp, herbs (32 spp) are used maximum. Leaves (34 %) are utilized maximum for medicines.

Punjani (2002 c), studied the ethno botanical plants used as contact therapy. Out of total 16 ethnobotanical plants, maximum 8 herbs were used. While, in case of utility of plant parts; roots were used maximum accounting to 42 %.

Punjani (2010), also carried out study on ethnobotanical plants used to cure Urinary complaints by tribals of North Gujarat. He reported total 49 spp. Among them, herbs were used maximum 24 spp. In context to plant parts, 28 % of roots were used as medicines; while only 10 % of seeds were used to cure urinary complaints.

Paul & Prajapati (2014), conducted research ethno botanical plants used to heal bone fractures in Dangs. Total of 20 spp were reported, out of which, 9 tree spp were used. Bark (41%) is used maximum to heal bone fractures.

Kandari *et al*. (2013), described utilization of weed species by tribals of Godhra & Baria Forests. Total of 19 weeds are used by tribals. Leaves & stem (52.60 %) are used maximum followed by roots (31.60 %) as medicines.

Patel, *et al*. (2013), studied the ethnobotanical aspects of Cucurbitaceous plants used by tribals of North Gujarat. They reported total of 24 plant species of Cucurbitaceae family used. Fruits of this 24 spp are used maximum (63 %) for curing various diseases.

Maitreya (2015), studied the ethno botany of Genus *Cassia* by tribals of Bhavnagar district. He reported total of 11 spp of genus *Cassia* is used as medicines. Out of the 11 species, *C. auriculata* (27 %) is used maximum (12 diseases) followed by *C. occidenatlis* (7 diseases), *C. tora* & *C. fistula* each are used to cure 05 diseases.

Cruz (2007), conducted study on ethno botany of leguminous plants used by Vasava tribes of Dediapada forests in South Gujarat Out of total 23 leguminous spp reported, tree spp (11) were used maximum. Bark (53 %) is utilized maximum as medicines. He also reported 34 new uses of leguminous plants for Gujarat state, out of which maximum 09 uses are found for curing jaundice.

Anjaria, *et al.* (2002), studied the ethno veterinary aspects in Gujarat state. Out of total 300 spp used, maximum 86 spp were used to cure Gastro intestinal disorders accounting to 29 %.

Punjani & Goel (2007), carried out research on ethnobotanical plants used to make Patoda in Patan. In all 29 spp are used as sources of natural dyes, out of which, 10 spp of trees & shrubs are used. 22 % of the flowers were used to prepare natural dye.

Patel (2015), investigated sacred plants worshiped by Bhils & Banjara tribes in North Gujarat. Total 33 spp are worshiped or are sacred, out of which, 15 tree spp are worshiped. Leaves (28 %) are used & only 3 % of rhizomes used as a part of religious ceremonies or different rituals performed.

Desai (2002), conducted research on cross cultural ethno botany i.e. multiethnic uses of plants within Gujarat state. In all 261 ethno botanical plants were reported from Chhota-udepur forests division in Central Gujarat. On comparing with other tribal inhabited regions of Gujarat state, 120 ethno botanical plants were found common between Dharampur & Chhota-udepur regions; 115 ethno botanical plants common between Dangs &

Chhota-udepur, 70 plants were common between Ratanmahal & C-udepur forests & 103 ethno botanical common between Saurashtra & Chhota-udepur regions.

Jha, *et al*. (2013), studied the utility of medicinal plants for curing various diseases by tribals of Dangs District. Total 98 ethnobotanical plants from 26 families were enlisted. Among them, 9 spp are used to cure stomach disorders followed by the ear & eye problems, tooth ache (5 & 4) respectively.

Patel (2013), conducted research on ethno botany of Kaprada Forest Division in South Gujarat. He reported total 123 plants species. Out of them, 52 trees, 45 herbs, 14 shrubs & 12 climbers are used as medicines. In context to plant parts, 34 % of leaves were used as medicines.

Conclusion:

It can be concluded that overall there has been considerable increase in number of publications as evident between 2001-2015.With respect to total publications (172), maximum research has been carried out in the region of North Gujarat with 47 publications (28 %) & least in Kachchh region (16; 9.30 %). Out of 172 publications, 123 accounts to general ethno botany (70.98 %), whereas other aspects like tribe specific, disease specific & specific plant group accounts to 49 publications (29.02%).Analysis of various publications reveals maximum usage of trees & herbs for ethnobotanical purposes. Leaves, bark & roots are used maximum by tribals residing in different parts. The total ethnobotanical folk lore of Gujarat comes to 1500 plants, out of which 450 (30 %) is used for non medicinal purpose; 750 (50 %) for medicinal purpose & 300 (20 %) for ethno veterinary uses. Even though South & Central Gujarat bestows vast plethora of floristic & ethnic diversity, it contributes only 22 % & 15 % research on ethno botany of Gujarat state. Way ahead, cross cultural ethno botany w.r.t multiethnic & multi usage research along with plants mentioned in folk songs, folk proverbs, witchcraft & ethnobotanical validation needs to be carried out extensively for Gujarat state.

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Seminar No. 33

Speaker: **Mr. Vikas Gamit**	Reg. No. 2030314003
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. Dr. V.M. Prajapati**	Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel**	Date: 05/12/2015

FOREST TREES — BIOLOGICAL NITROGEN FIXERS

Nitrogen fixation is a very important biological process, playing a large role in the nitrogen cycle in nature and enriching the soil with bound nitrogen. The atmosphere covering one ha. of ground, contains over 70,000 tons of free nitrogen, as a result of nitrogen fixation and a portion of this becomes available to higher plants. Free living nitrogen-fixing bacteria bind several kilograms of nitrogen per ha per year. The quantity of nitrogen fixed into the soil by legumes because of the activity of Rhizobia accounts to 100-250 kg per ha in a season. *Leucaena leucocephala* fixed 100-500 kg N $ha^{-1}yr^{-1}$. Naturally, this process has great significance for the improvement of soil and for increasing the yield of agricultural crops.

Brief Review of Research Work:

Pokhriyal et al. (1996) reported maximum nitrogenase activity in three tree species viz. Acacia, Ougeinia, Robinia during summer season, whereas in other three tree species Albizia, Dalbergia, Pongamia recorded maximum nitrogenase activity during rainy season. Maximum nodule number per plant was reported during rainy season.

Pokhriyal *et al.* (1997) reported that maximum nodule fresh weight 2.915 g, dry weight 0.5 g and 40 nodules per plant was observed in *Erythrina blakei.* Whereas maximum nitrogenase 2787.96 per g/ha and 1681.14 $pl^{-l}h^{-1}$ N moles acetylene reduced activity was observed in *Dalbergia sericea.*

Srivastava *et al.* (1999) observed highest number of nodules (17.78) and dry matter weight (5.69 g) in *Albizia lebbek.*

Hoogmoed *et al.* (2014) revealed that total N content was higher in leaves and litter of the N-fixing trees compared with the non-N-fixing trees. In the soil layers, total N content was significantly higher under *Acacia dealbata* compared with *Acacia implexa.* Carbon content was higher in samples of *A. dealbata* compared with *A. implexa.* The C:N ratio was significantly higher in *Eucalyptus polyanthemos.*

Maria and Jennifer (2013) quantified the mean ratio of extractable NO_3^- to NH_4^+ ranged from 1.60 to 4.45 for *Dalbergia retusa* and 1.06 to 5.85 for *Gliricidia sepium.The* non-legumes *Quercus oleoides* and *Swietenia macrophylla,* which had much lower concentrations of extractable soil NO_3" relative to NI-1_4^+, with ratio from 0.11 to 0.35. *Acosmium panamense* showing the highest net N mineralization and nitrification at both forest and plantation sites. In the forest, *Dalbergia* had the highest value of total soil C and N. The plantation of the legume *Acosmium* had the highest concentrations of total soil C and N.

Bouillet *et al.* (2008) found that the total amount of nitrogen taken up by trees over 30 months after planting in 100A:0E, OA:100E and 50A:100E treatments were about 445.5, 375.5 and 410.7 kg N/ha, respectively.

Kumar *et al.* (1998) stated that intercropping of *leucaena* promoted height and diameter growth of teak. Teak growth increased with increasing relative proportion of *leucaena* in the mixture. Implicit in this growth stimulation of teak by intercropped *leucaena* due to its nitrogen fixing ability and potential as a soil improver.

Aronson *et al.* (2002) reported that *Chamaecytisus proliferus* can fix approximately 8, 73.8, 45.0, 193.2, 46.5 and 49.3 kg N/ ha in the first, second, third, fourth, fifth and sixth year of field growth and 415.8 kg N/ ha over six years. December to April. Highest accretion was observed in the months of September, October and November 1981 in the entire stand, accepting the 7-year-old stand. The 7-year stand had the highest accretion between the months of June and August.

Wang *et al.* (2010) observed net N mineralization rates were high in the rainy season, ranging from 7.41 to 11,3 kg N/ ha/month, but negligible or even negative in the dry season and soil nitrification rates were much lower in the dry season than in the rainy season. Highest N mineralization in *Schima superb.*

Freitas *et al.* (2010) found highest N content in the Remigio site (3.23%) while the lowest in Santa Teresinha (1.93%). The fixing legumes had a mean content of 3.10%, while the non-fixing had 2.48% of N in the dry biomass of the leaves.

Conclusion

Total biological N2 fixation is 175x 10^6 metric tons per year. Biological nitrogen fixation (BNF) promotes faster growth of plants and soil life, relevantly with high economic significance. BNF trees are ideal for land reclamation and others can be the basis of sustainable forestry and biomass production. BNF tree species enhance the sustainability of crop production by increase in soil organic matter, improving the long term N reservoir of the soil moisture content.

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Seminar No. 34

Speaker: **Ms. Jharna Chettri**	Reg. No. 2030314007
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. Dr. V.M. Prajapati**	Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel**	Date: 19/09/2015

EFFECT OF WINDBREAKS ON CROPS

The shelters created by windbreaks have a significant and positive effect on agricultural production. Fruit and vegetable growers face the challenge of producing high quality annual and perennial crops with a high percentage of marketable fruit under ever-increasing environmental standards. Many of these operations are located in areas subject to high winds, blowing soil and limited rainfall. To be successful, these operations must optimize the balance between inputs and final yields. Wind protection is one method to enhance growing conditions, improve yield and quality of crops while contributing to improve environmental conditions. Tree or shrub windbreaks, tall annual crops or artificial barriers such as slat fence can provide wind protection (Hodges and Brandle, 2006).

Review of Research Work

Kumar and Buvaneswaran (2012) concluded that IFGTB-WBC 8, IFGTB-WBC 17 and IFGTB-WBC 18 clones of Casuarina performed best in all the parameters like number of branches up to 2 m, branch length, branch angles and height growth, so these clones can be used in windbreak agroforestry system.

Helfer *et al.* (2009) revealed that the maximum monthly evaporation rate was higher in the month of March for different windbreak protection scenarios and minimum was found under 40m high windbreak. Moreover, reduction in annual evaporation levels of only 2.5, 3.6 and 5.6% achieved for 20, 30 and 40m high windbreaks respectively.

Bains *et al.* (2005) concluded that the soil temperature was more under the sheltered plots as compared to the open plots. The maximum increase in soil temperature was observed under first date of sowing followed by second and third date of sowing.

Suratman *et al.* (2004) concluded that mean seasonal wind speeds in shelter were significantly reduced in for each planting period. Again, air temperature, soil temperature and soil moisture parameters were higher in sheltered plots than the exposed areas for each planting throughout the growing season where as relative humidity was higher throughout the growing season in sheltered plots. Similarly, air GDD_{15} was slightly higher in the sheltered areas than in exposed areas for all plantings and found differences were non-significant. However, the greater soil GDD_{15} for all sheltered plantings was significant.

Bao *et al.* (2012) stated that the tree belt of 0.5m and 1.5m high were able to reduce the wind speed by 0 % and 25% respectively at a distance of 5H.

Eckstein *et al.* (1997) found higher total leaf count in the shade for both P (Planted) and RI (Ratoon) crop. The reproductive cycle (flowering to harvest) of the P crop was found to be longer and in the RI cycle no reduction in flowering to harvest interval due to windbreak shading effect recorded.

Singh and Tripathi (1998) suggested that the growth of Teak plants was affected by the windbreak and the per cent reduction in growth parameters like height, DBH and collar diameter decreased with increase in distance from the windbreak.

Campi *et al.* (2008) stated that production of wheat tends to diminish with the increase of distance from the barrier. Finally, in the unprotected area production remains constant because it is not influenced by the windbreak.

Bains *et al.* (2005) recorded maximum pod yield of pea crop under sheltered plots as compared to the open plots. Among different dates of sowing, yield was more under first date of sowing followed by second and third date of sowing under sheltered plots.

Eckstein *et al.* (1997) concluded that wind exposure in unprotected plantation showed its greatest impact on bunch mass reduction of banana. No significant difference in yield over two cycles was measured between banana grown under natural conditions outside the windbreak and plants growing in the seasonal shade of the windbreak.

Suratman *et al.* (2004) found that the cultivar 'Rushmore' produced 57% total yield than the cultivar `Strike' in 1994 and 60% more in 1995. Total and marketable pod yields were significantly increased by shelter in both 1994 and 1995.

Nandal *et al,* (1999) revealed that number of earheads/m^2, test weight (g/100 seeds), grain and straw yield increased almost consistently away from the tree line. Moreover, no significant increase in any parameter was noticed beyond llm distance from the tree belt.

Sun and Dickinson (1994) concluded that total and grade A potato production increased in between 0.94h and 12.26h, decreased in the areas between 12.26h and 25h and became relatively constant after the distance of 25h. At the distance of 0.94h, both the total and grade A potato yield were the lowest of all the distances measured which were 27.9% and 22.1% less than the average yield at the open area, respectively.

Chaput and Tuskan (1990) reported higher test weight of wheat for the plots immediately adjacent to the windbreak compared to test weight taken 10 times farther from the windbreak. The parameters like yield, average ear length and kernels per ear were found to be highest at 5H distance.

Campi *et al.* (2009)concluded that the evapotranspiration, wind speed, relative humidity and air temperature were decreased and wheat yield was increased in the zone of 0 to 5H.

Sharma *et al.* (1996) revealed that plant density, height and fodder yield'of *Sorghum vulgare* (chari) crop increased with increase in distance from tree line in both plantations (East-West and North-South).

Lyles *et al.* (1984) concluded using mean yield difference between pruned and unpruned windbreaks that pruning would provide more yield than unpruned condition.

Bao *et al.* (2012) reported that the WTG (weights of thousand wheat grains) and winter wheat yield increased in the areas between 1 H and 15 H whereas decreased in the areas nearby the windbreak between 0 and 1 H and more than 15 H.

Conclusion:

Windbreak act as a wind barrier to reduce the wind speed and enhances the productivity of crops. It also improves the crop growth, yield and microclimatic conditions like air temperature, soil temperature, soil moisture and relative humidity. So, windbreak positively influences the crop growth and yield.

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Seminar No. 35

Speaker: **Mr. Jilariya Devanand J.**	Reg. No. 2030314008
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. N. S. Thakur**	Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 03/10/2015

ETHNOBOTANICAL PERSPECTIVE OF TRADITIONAL AGROFORESTRY SYSTEMS

As a discipline, ethnobotany seeks to understand the place of plants in the humanized world by proposing and testing the hypothesis concerning the relationships between humans and the plant kingdom. Ethnobotanical data may be generated from the local knowledge of people living inside the forests and in neighbouring areas. Not only forest areas can provide ethnobotanical information but other land use systems also harbour various plant forms being used by the rural as well as semi urban people based on their traditional knowledge and wisdom. Agroforestry, as one expression of human/plant relationship, fits comfortably within the expansive sweep of ethnobotany (Bates, 1998). Agroforestry is an age old land use where trees/shrubs/herbs/crops are integrated/allowed to grow according to agroclimatic and other prevailing conditions. Many traditional agroforestry systems (including home gardens) are devised by the people in pursuit of their livelihood goals of income generation, risk management, household food security, health benefits and optimal use of available land, labour and capital. Thus, these complex agroforestry systems are source of various ethno-medicines and other numerous uses, information on which is being documented and such local knowledge can be utilized as means of conservation and pharmacological purpose to benefit the society.

Brief Review of Research Work:

Javaid *et A,* (2009) in tiller extensive explorations, reported of 60 woody plant species (47 trees and 13 shrubs) associated with the agroforestry system. Out of these, 47 species are reported to be used as fuel, 30 as medicine, 22 as edibles, 13 as fodder, 7 as timber, whereas 4 species were found to be used for making agriculture implements.

Kour and Sharma, (2014) analyzed distribution pattern, diversity and phytosociology in different traditional agroforestry systems and reported 17 tree species with ethnobotanical uses like medicine, fodder, fuelwood, timber, furniture, boat making, carving, religious, etc.

Kala, (2010a) documented a total of 26 herbaceous food crop species and 21 woody species raised/retained by farmers in tradional agroforestry systems in the selected villages of Uttarakhand being used for curing various ailments by traditional healers.

Rawat and Vishvakarma, (2011) studied the diversity, distribution and utilization pattern of the fodder species in traditional agroforestry systems in Kullu and Lahaul valleys. Out of 67 fodder species, 43.28% were trees, 26.87% small trees and 29.85% shrubs, respectively. Apart from fodder production. these species are used as fuel, ethnomedicines, fruit, timber, fibre, agricultural implements etc.

Deb *et al.,* (2009) carried out studied the ethnobotanical studies in traditional agroforests of Nyishi community of Arunachal Pradesh. In total of 80 useful plants belonging to 45 families and 69 genera were

reported in 20 randomly selected agroforestry plots. Among these 47 species are used for food, 21 species are used in medicine and other purposes like food, house building, timber, fuel, broom making, etc.

Deb *et al.,* (2014) studied the traditional agroforestry systems practiced by the rural people of Tripura, North East India. The total number of woody and herbaceous species recorded in the agroforestry system were 44 and 49 respectively. Documented plants are providing day to day needs of food, timber, vegetables, fruits, cereals, house building material and ethnomedicnes.

Kala, (2009) studied the native uses of plants in the south Surguja district of Chhattisgarh and documented total 73 ethnobotanical species, of these 36 species are used in curing different types of diseases and 22 as edible food and others as fish poison, dye, beverages, etc.

Kala, (2010b) documented 47 (21 trees, 8 Shrubs, 18 Herbs) species, ranging from forestry to horticulture and agricultural nature, grown in the home gardens in Panchmarhi, (M.P.). These species are being used for multiple purposes including food, medicine, vegetables, nutraceutical, fodder and also have cultural significance.

Bhat *et al* (2014) surveyed 50 home gardens of Karwar, Karnataka to document their floristic diversity and composition with regard to life forms and uses. As many as 210 species of flowering plants belonging to 69 families were recorded. Out of total 41 plant species are grown mainly for ornamental and aesthetic purposes while 46 species are used for ˙o'Jtaining food products like fruits and vegetables and 32 plants are mainly used for medicinal purposes, 7 have other miscellaneous uses.

Vijayan and Gopakumar (2015) studied diversity of shrubs in homegardens in Cherpu, Kerala and reported 23 multipurpose shrub species being used for various purposes like medicine, edible, ornamental, fuel wood, and other uses.

Conclusion:

The local wisdom and experience of aboriginal and non aboriginal communities results in diversified traditional agroforestry systems (including homegardens) with variety of useful species, either active cultivation or purposefully retaining the naturally regenerated species. Indigenous agroforestry systems not only supports the livelihood throut production of ethnomedicines, food, fodder, firewood, timber, spices, fibre, protection functions etc, but also serve means of conservation. The species diversity and their utilization pattern varies according to region and needs of the people. Thus, traditional agroforestry systems have great ethnobotanical treasure which is being utilized by local people and the same can be utilized for benefit of society.

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Seminar No. 36

Speaker: **Mr. Jitendra Patel**	Reg. No. 2030314009
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. Dr. D. Nayak**	Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel**	Date: 17/10/2015

CEREAL BASED AGROFORESTRY SYSTEM

The world's population is set to grow considerably over the coming years. albeit at a slower rate than in the past. and with considerable differences across regions. Over the next four decades. the world's population is forecast to increase by 2 billion people to exceed 9 billion people by 2050 (FAO, 2012). In India the score of hunger category is 3 *i.e.* the status of hunger is moderately high. About 17.5 per cent of population in India is undernourished. The food security situation is affected by poverty, uneven food distribution, natural disasters, deforestation and low education levels. Cereals are the most common and important food source for human consumption. Cereals are the world's most important sources of food. both for direct human consumption and indirectly, as inputs to livestock production. What happens in the cereal sector is therefore crucial to world food supplies. Also, there is increasing gap between demand and supply of forest products leading to areat pressure on natural forests. To reduce this gap, there is need to expand the land under tree cover by way of plantations and other afforestation works (Wani and Malik, 2014). But the horizontal expansion of land under tree cover is not possible. In such situations agroforestry is one of the viable options to increase the area under tree cover. There are many sustainable aaroforestty systems in voaue in many parts of the world. There is ample scope for supply both foods as well as tree products in sustainable way through agroforestry systems in already existing maximum area covered under cereal crop productions.

Brief review of research work:

Panwar and Chakravarty (2011) studied the three rice based agrisilviculture systems at two spacing (6x6m and 6x3m) in Terai zone of West Bengal. It was found that *Salix tetrasperma* was the best tree out of the three tree species taken as its canopy allowed more PAR above paddy (1305.1 1 i.tmols^{-i}m^{-2}) to penetrate and had less LAI (2.78). As a result the yield of paddy was more (3.79t/ha). The best combination of species and distance from tree was *Salix tetrosperma* (6x6m) at 3m distance from the tree as the highest yield was 4.01 t/ha., PAR above paddy (1383.66 µmols^{-1}m^{-2}) and lowest LAI (2.18).

Kumar *et* al (2011) reported that agricultural crops, grain yield of wheat was not affected by clonal transplantation, however, yield of rice significantly affected by willow clones and highest Grain yield (49.5q/ha) of rice recorded under plots where salix clone UHFS-3 were planted.

Gandhi and Dhiman (2010) investigated on Poplar-wheat based agrisilviculture system. Poplar trees put significantly greater height and DBH growth at 7x5m and 6x1.5m. Wheat crop grown under 6x6m tree spacing had produced maximum grain yield, harvest index, straw yield, number of spike/m^2, length of spike, number of fertile spikelets/spike, number of grain/spike, weight of grains/spike and weight of 1000 grains; whereas wheat under 6x 1.5m tree spacing produced maximum number of sterile spikelets/spike when compared with that of other spacing.

Yadav *et al.* (2005) reported that significantly least reduction in grain yield of wheat cv. Raj. 3765 beneath canopy of *P. cineraria* (6.85%) followed by *A. leucophloea* (19.28%), *D. sissoo* (38.27%) and .4. *nilotica* (47.33%) in comparison to no tree control (36.66q ha^{-1}). Uptake of N, P and K by grain and straw of wheat under canopy of tree species followed the similar trend of grain and straw yields.

Sharma *et al(2012)* studied the wheat association with boundary plantations of poplar *(Populus deltoides* M.). Maximum reduction in dry matter accumulation in wheat was observed near the tree line (0-3m) under both three- as well as four-year-old plantation (21.1 and 17.8 per cent under three- and four-year-old trees. resp.) which tapered off beyond that, but synergetic effect caused by existence of trees increased dry matter significantly between 3-6m distance and 6-9m distance under both three as well as four-year-old

plantation. Similarly, minimum concentration of nutrients (nitrogen, phosphorus, and potassium) as well as their uptake in wheat plants was observed near the tree line (0-3m) and increased subsequently with increase in distance from tree line.

Chauhan *et al.* (2011) assessed the productivity as well as the carbon sequestration potential of poplar -wheat mixture. Wheat crop yield decreased under poplar but this may be compensated by the poplar trees in terms of biomass, economic returns and the carbon sequestration potential.

Chauhan *et al.* (2012) reported maximum yield of wheat and paddy on Southern aspect (4.11 t/ha and 5.06 t/ha, respectively), whereas, it was found minimum on Northern aspect (2.5 t/ha and 4.13 t/ha, respectively). In control conditions wheat and paddy yield was 4.47 t/ha and 6.96 t/ha, respectively.

Singh *et al.* (2003) studied the effect of *Eucalyptus* plantation on yield of wheat crop. The yield attributes and grain yield of wheat decreased significant with successive increased in shade level from S_{24} (18-24m) and S_6 (0-6m) during both the years except effective tillers per plant and test weight between S_{12}, (6-12m) and S_{18} (12-18m). The quantum of decreased in grain yield with increased shade was 44.6%, 21.2%,10.8% and 50.9%, 29.5%,9.6% during 1999-2000 and 2000-2001, respectively.

Abugre *et al.* (2015) find out the compatibility of *Jatropha cwcas* ith maize in agrolorestry system. Maximum yield of maize was 4.47 tons/ha and 2.99 tons/ha in the first and second year respectively at the control treatment.

Group of scientist tested their hypothesis that deciduous *(Paulownia fortunei)* (Hemsl.) and semi-deciduous *(Alnus acuininata* (HBK)) trees are less competitive with maize crops than evergreen species *(Grevillea robusta* (A. Cunn.)). A positive interaction between *A. acuminata* and maize was apparent at Thika. but growth was suppressed in the first two crop rows at NaroMoru. *G. robusta* reduced maize yield by 36% close to the tree rows at Thika. whereas yield reductions were negligible adjacent to *P. fortunei.* These findings suggest there was some complementarity of resource use between A. *acuminata* and maize at Thika. and neutral or competitive interactions between trees and crops in all other treatments (Muthuri *et al*,. 2005).

Kaushik and Jagadev (2001) reported that tree spacing on has not any significant influence on the yield of pearl-millet during the first year. Maximum grain and straw yields of pearl-millet were recorded under sole cropping. The grain and straw yields of pearl-millet were significantly less under 5x3m geometry as compared to sole cropping during second year. The grain and straw yields of wheat were maximum in sole cropping. However, the yields obtained under various plant geometries of poplar were statistically at par to sole cropping treatment.

Nandal and Hooda (2005) found that yield of sorghum crop decreased with advancing age of poplar. The yield increased with increasing row spacing from 5x4m tol5x2.5m. However, during the first year yield decreased under different spacing of poplar as compared to control.

Mutanal *et al.* (2009) studied the long term experiment on agroforestry involving arable crop (sorghum), silvicultural crop (teak), horticultural crop (papaya) and pasture crops (subabul and guinea grass). Grain yield of sorghum was significantly higher in 20 m alley of teak+papaya rows as compared to 10m alley of teak+ papaya.

Deiss *et al.* (2014) studied the oat production; tillering, persistence is the determinant of one important yield component, .namely the number of panicles. The objective of this study was to determine how the tillering persistence for grain production and oat *(Avena sativa* L. cv. 'IPR 126') tiller traits were influenced by nitrogen levels (12 and 80kg N/ha) at five equidistant position between two adjacent eucalyptus *(Eucalptus dunnii* Maiden) double line tracks [20m (4mx3m)] in ACS and traditional no-ti agriculture in subtropical Brazil. The oat tillering persistence for grain production is dependent on different nitrogen levels at distances relative to adjacent eucalyptus tracks and therefore. different nitrogen levels should be used in those areas. to improve oat yield potential inside ACS in subtropical Brazil.

Conclusion:

From the foregoing discussion it can be concluded that the cereal crops can be grown along with trees in proper spatial and temporal management under the agroforestry system to supply food and tree products of growing demand of increasing population. The yield of cereals

decreased with.advancing the age of perennial crop. By adopting wider spacing the reduction in yield of cereals can 'be managed. The deciduous and semi deciduous tree are less competitive with cereals as compared to evergreen tree species.

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Seminar No. 37

Speaker: **Mr. Patel Rahul M.**	Reg. No. 2030314010
Degree: M.Sc. Forestry (Watershed Management)	Course No: FOR-591
Major Adviser: **Dr. Dr. P.K. Shrivastava**	Venue: Conference Hall
Minor Adviser: **Dr. Dileswar Nayak**	Date: 17/10/2015

EFFECT OF CLIMATIC FACTORS ON FOREST SPECIES

Climate is defined as the average weather conditions prevalent in any locality. though it is dependent on various meteorological and weather conditions. Therefore, climatic factors like light, temperature. humidity. wind and other features of climate - regional, local and seasonal basis influence vegetation. Thus the climatic factors could be classified as under: 1) Solar radiation —Light, and Temperature, 2) Moisture

and 3) Wind. Understanding the effects of site conditions and climatic factors on forest growth is important for the development of forest cover and forest management. The seeds definitely require moisture, temperature, and air and to some extent light for germination. These factors, which form part of climate of a place, are also required by plants for their growth. Thus climate exerts a great influence on the vegetation of a locality (Khanna, 1981).

Brief Review of Research Work:

Rattan and Tomar (2013) studied about the effect of different lights on seed germination of *Hippophae salicifolia* at three different places. They found maximum germination percentage at Chamoli under red light (89%) followed by yellow light (85%) in Uttarkashi. Whereas, minimum germination was observed in green light (50%) at Chamoli. The maximum negative influence was observed in green light (-37.5) followed by blue light (-31.25) in Chamoli. However minimum negative influence was observed in red light (-1.19) followed by yellow light (-4.76) in Pithoragarh. Site Pithoragarh showed negative influence on seed germination in all the lights under study. They concluded that light is an important factor affecting germination.

Phonguodume *et al.* (2012) studied the growth performance. biomass allocation and chlorophyll content of *Afzelia xylocarpa* Craib, *Anisoptera costata* Korthals, *Dalbergia cochinchinensis* Pierre. *Dipterocarpus alatus* Roxb. and *Hopea odorata* Roxb. Seedlings were compared under different light intensities (100%, 50-70% and 30-50%) in Lao PDR. The result revealed that the number of leaves showed strong relationships with species characteristics and light. *D. cochinchinensis* and *A. xylocarpa* had highest number of leaves, 35 and 23, respectively, when grown at high light intensity levels. *D. cochinchinensis* need full intensity sunlight for maximum (35) leaves production while *A. xylocarpa* produces highest leaves (25) at partial to full range of light.

Yang *et al.* (2006) estimated the possible effects of site factors and climate change on forest growth in the Taihang Mountains, northern China. These results suggest that temperature is a major factor influencing forest growth. Generally, low temperature was more favourable for forest growth in the Taihang Mountains. Forest growing stock (FGS) growth at sites below 6°C was almost doubled than above 6°C and dropped at a rate of about 2.5 per cent. The effects of temperature d.b.h. were nearly the same except in the warmest group; in which it was significantly lower than in any other group. Tree height did not exactly decrease with increasing temperature.

Parvaneh and Valipour (2012) studied the correlation between climatic factors with *Quercus brantii* tree ring growth at similar geographical condition. The effects of temperature and precipitation on tree ring were investigated by using a statistical analysis for a 20 years period. The results showed that the tree ring width had a strong correlation R=0.82 at 99% confidence level with mean annual precipitation before growth season, while the correlation is very low for the same growth year (R=0.48). Also the minimum peaks of tree rings are synchronic with the annual number of frost days. They inferred that rainfall in autumn and winter before the growth season could have major role in growth ring of *Q. brantii* Lindl in the region. Due to this condition, the strongest correlation of growth rings was established with previous year annual precipitation before the growth season. However. the correlation with rainfall year and growth was weak.

Anonymous (2004) studied about the impact of fire and climate change in the forests of Kilimanjaro ecosystem and found that reduction in rainfall along with increased temperature is the major factor of change in Kilimanjaro ecosystem. Besides the melting of the ice cap, these changes have impacted tremendously on the forest by increasing its vulnerability to fire. Between 1976 and 2000, fire destroyed approximately 15,445 hectares of Erica forest, representing 83 percent of that forest type.

Yang *et al.,* (2006) studied the effects of precipitation on forest growth in the Taihang Mountains, northern China. They found that precipitation is one of the most important factor directly influencing FGS. d.b.h. and tree height in semi-arid and semi-humid regions. Differences in FGS, d.b.h. and tree height among the four precipitation groups were analyzed by one-way ANOVA. The differences were statistically significant *(P* 0.01). The effects of precipitation on d.b.h. were nearly the same except for

the pair of 550.0 — 649.9 and 650.0 — 749.9 groups. The effect of precipitation on tree height did not showed significant change.

Sinha *et al.,* (2011) studied climatic variability on growth of teak *(Tectona grandis* L. f.) on the basis of response function analysis from dry deciduous forests of Mundagod (Karnataka) and Chandrapur (Maharashtra) peninsular India which represent two ecological zones. They found that rainfall during the monsoon months of the current year was positively associated with radial growth of teak at both sites, whereas, pre-monsoon April rainfall was found to be negatively associated. Rainfall and temperature of the current year during March have positive influence on the growth of teak at Chandrapur and Mundagod respectively. Furthermore, rainfall during October of the preceding year showed negative influence on tree growth at Mundagod and positive influence at Chandrapur.

Bharali *et al.,* (2012) studied growth of two Rhododendron species viz. *Rhododendron kenderickii* and *Rhododendron grandewere* at an attitudinal gradient in a temperate forest. The highest relative growth rate in terms of height and collar diameter was observed during the rainy season and minimum in the winter. Moreover, both the selected species showed significant variations in growth rate among the study stands as well as in seasons. *R. kenderickii* exhibits significant seasonal as well as attitudinal variation of relative growth rate in terms of height. However, variation of growth rate in terms of collar diameter was found significant only in seasons.

Rathore and Jasrai (2014) analyzed past 50 years (1957-2007) data and found that there is an increase in the annual mean maximum temperature of Gujarat by 1^0C. the mean summer temperature by 0.1^OC and mean winter temperature by 0.4^OC. The flowering and fruiting time has been delayed in 24 tree species of 20 genera belonging to 16 families and has advanced in 31 tree species of 28 genera belonging to 19 families, by a period of one to three months.

Singh *et al.,* (2004) studied the effect of soil water availability with irrigation treatments T_1, T,, T_3, T4 and T5 as 36.2 mm. 26.5 mm. 20.2 mm, 18.1 mm and control (34 mm) respectively on dry biomass (g/plant) at different ages. They found that at the age 24 months carbon(C) accumulation in the plant of T_i treatment was 17.7-fold in *Eucalyptus camaldulensis,* 18.6-fold in *Acacia nilotica* and 28.6-fold in *Dalbergia sissoo* as compared to T.,. Carbon sequestration potential increased with age of the plant of *E. camaldulensis* (20.6-fold), and *Dalbergia sissoo* (35.0 fold) at the age of 48 months. Plants in T_2treatment, the reduction in C sequestration was about 15% at the age 24 months: the reduction however, reached 30% at the age of 48 months. This indicates that low soil water availability for longer period affected biomass accumulation. They concluded that biomass in the plants varied with the irrigation levels that had affected carbon sequestration. Treatment T_1 was the best irrigation level in which all the three species accumulated the highest amount of carbon. It also indicated higher adaptability *A. nilotica* towards decrease soil water availability and less by *Dalbergia sissoo.*

Nataraja *et al.,* (1998) carried out experiMents on the influence of elevated CO_2, concentration and relative humidity (RH) on seedling growth of *Eucalyptus citriodora, Derris indica, Spathodea campanulata and Acacia auriculiformis.* Results from the study found that plant height showed significant increase due to CO, and RH enrichment. Exposure of plants to elevated CO, and RH resulted in 39 per cent increase in plant height compared to the plants grown at ambient CO, levels and response by *Derris indica* was maximum. Among the four species studied, *Derris indica* showed 223% increase in leaf area under elevated CO, and RH treatment, whereas in the other species the increase ranged from 46 to 173 per cent.

Sundarapandian *et al.,* (2014) studied about the defoliation, uprooting and snapping of stems and branches of trees due to heavy wind along with high rainfall during catastrophic windstorm. .A total of 1181 (20%) trees (>3.2 cm DBH) in Pondicherry University Campus were uprooted due to the Thane cyclone. Tree mortality (uprooted) and damage (broken) were observed more in *Acacia auriculiformis* than other species in response to Thane cyclone. Wood density did not show any significant relationship between the damage, mortality and resistance (standing with defoliation and minor branch fall). *Acacia auriculiformis* was more susceptible followed by *Tectona grandis* to Thane

cyclone, however *Azadirachta indica* and *Maangfera indica* were observed more resistance. The greater uprooting in introduced plantation species such as *Acacia auriculiformis* and *Tectona grandis* was higher th native species *Azadirachta indica* and *Mangifera indica.*

Parmar *et al.,* (2012) inferred that high night temperature which prevailed during December to February at the time of flower induction caused poor flowering in mango, ultimately affecting the crop yield.

Conclusion:

Climatic factors are mainly responsible for the presence of large number of species and multiplicity of forest types. Climatic factors affecting species are light, atmospheric temperature, humidity and wind. Light plays an important factor affecting germination and seedling growth. Number of leaves in a tree show strong relationships with light in addition to species characteristics. Temperature is a major factor influencing forest growth.There exist a strongest correlation of between rainfall and tree growth rings. Reduced precipitations along with increased temperature are major factors responsible for forest fires. Precipitation directly affects FGS, D.B.H. and tree height. The highest relative growth rate in terms of height and collar diameter was observed during the rainy season and minimum during winter season. Fluctuation in temperature and precipitation promotes the growth of some plants while making some sensitive species vulnerable to the change. Low soil water availability for longer period affects biomass accumulation and biomass in plants varies with the irrigation levels ultimately affecting carbon sequestration, while, relative humidity helps in maintaining cell turgidity and hence helps in leaf expansion; however, it may vary among species. High wind velocity during cyclone uproots trees, though it varies depending upon the rooting pattern. Flowering and fruiting behaviour due to climatic variations affects fruit yield.

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Seminar No. 38

Speaker: **Mr. Sagar Patel**	Reg. No. 2030314011
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. D. Nayak**	Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 17/10/2015

STATUS OF AGROFORESTRY SYSTEMS IN GUJARAT

Today about 7.08 billion people inhabit on the earth. Presently to feed every one adequately the world needs 2800 million tonnes of cereals, against which global production is only 2100 million tonnes. This discrepancy in need and production has left over 868 million people undernourished worldwide and 850 million of them live in developing countries (Tiwari *et al.* 2014). Man's desired to live in peaceful coexistence created settled agriculture. In India order to meet the increasing demand of our fast growing population, we would require to boost the production of food grain and fuel wood for human consumption and green and dry fodder for livestock. Agroforestry is an old land use where trees/shrubs/herbs/crops are integrated/allowed to grow according to agroclimetic and other preventing conditions. Thus, Agroforestry systems are devised by the people in pursuit of their livelihood goals of income generation, risk management, household food security, health benefits and optimal use of available land, labour and capital. Hence, the present seminar is designed to address the current status of agroforestry in the state.

Brief Review of Research Work:

Jaimini and Tikka (1998) studied khejri based agrisilviculture system and observed higher income from khejri based agrisilviculture system then the sole raising of crops. They reported the income was maximum when clusterbean was raised as intercrop in between khejri rows.

In silvopasture (khejri+dhaman grass) system under rainfed condition, higher fodder yield were obtained below khejri canopy as compared to sole raising of dhaman grass as per Jaimini and Tikka (2001).

In another study Jaimini and Tikka (2007a) studied that the higher gross income was realized with ber + green gram closely followed by ber+sorghum and further intercropping in ber had higher monetary returns over ber fallow system. But, maximum economic returns obtained under Ber + green gram system.

Jaimini and Tikka (2007b) also investigated that ardu based agroforestry using different aerable leguminous crops. They indicated that there is reduction in production of crops under agrisilviculture system as compared to sole crop. However, maximum significant economic returns obtained under ardu + green gram system as compared to sole and other agroforestry production systems.

Bhusara (2014) estimated the economics of various agroforestry systems prevailed in South Gujarat. The author reported that Agrihorticulture system record maximum return followed by Hortipastural system. But, Agrisilviculture system gave lowest economic returns among, all studied agroforestry systems.

Prajapati (2006) estimated the economics of turmeric grown under 3 different tree species *Mitragyna parvifolia, Casuarina equisetifolia* and *Terminalia arjuna* in navasari district of Gujarat and found that the combination of *Mitragyna parvifolia* and turmeric cv. Keshar gave maximum economic returned as compared to other tree and turmeric based agroforestry systems.

Ahir (2006) conducted an experiment with different tree species like *Terminalia arjuna, Mitragyna parvifolia* and *Adina cardifolia* along with colocasia as silvihorticulture system of agroforestry. Significantly maximum yield as well as economic returned was obtained in *Terminalia arjuna* with colocasia as compared to other production systems.

Kumar (2009) investigated on performance of different of maize varieties under hortisilviculture based agroforestry system in Navasari, Gujarat. Among the different varieties tested cv. Ganga safed-2 gave significant production (104 kg/ha) of maize as compared to other varieties in the system.

Patel *et al. (1992)* studied the feasibility of growing of different grass species under subabool tree and reported more green forage as well as dry matter produced under silvopastural system. Crude protein is also higher in silvopasture system then the sole crop.

Verma (1991) conducted a survey on response of peripheral and mixed planting in irrigated and rainfed conditions of agroforestry system on crop productivity in Gujarat state. It was reported that mixed planting in irrigated conditions is less negative impact as compared to peripheral planting of trees in rainfed condition of Gujarat.

Anon. (2009) has reported the different silvopastural system in RRS, Bhuj of Gujarat. It was reported that neem recorded maximum height in both the grass species even as compared to sole planting, However, Neem found better growth under *C. setigerus* grass as compared to other silvopastural systems. Among the grass species, *C. ciliaris* was found to be superior to *C. setigerus* in terms of fodder production. In another study, the growth of grasses, *C. ciliaris* in terms of dry matter yield was least reduced under Neem (33.5%) followed by subabool (37.3%) and Israeli babool (43.45%).

Dayal *et al.* (2014) documented the carbon sequestration potential of silvipastoral and pastoral systems in arid northwest India. Maximum carbon was sequestered by silvipastoral system involving acacia + *C. ciliaris* (6.82 Mg C ha^{-1}) followed by Acacia + *C. setegerus* (6.15 Mg C ha^{-1}) compared to 6.02 Mg C ha^{-1} sequestered by acacia planted alone. The silvipastoral system involving neem + *C. ciliaris* and neem + *C. setegerus* registered a total carbon stock of 4.91 and 4.87 Mg C ha^{-1} respectively, against sole cropping of neem that recorded 3.64 Mg C ha^{-1}. The silvipastoral system sequestered 36.3% to 60.0% more total soil organic carbon stock compared to the tree system and 27.1-70.8% more in comparison to the pasture system. Thus, silvipastoral system involving trees and grasses can help in better sequestration of atmospheric system compared with systems containing only trees or pasture.

Conclusion:

From the current discussion, we may conclude that different agroforestry systems are found according to their agroecological conditions in the state. In North Gujarat and Saurashtra zone maximum studies were under taken for fodder as well as pulse crop productions, however in South Gujarat have covered more studies on various crops grown in this region. But in case of middle Gujarat; very little and scanty report on agroforestry system is available. Hence, there may be ample scope for further research and development of agroforestry systems in future for better resource utilization for foods and tree produce.

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Seminar No. 39

Speaker: **Mr. Pritam Choudhury**	Reg. No. 2030314012
Degree: M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. Manmohan J Dobriyal**	Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 17/10/2015

RESEARCH ON INDUSTRIAL AGROFORESTRY TREES IN INDIA

As the people-land ratio grows, multiple-use techniques are needed to increase land-use outputs. One of the most promising tool to maximize outputs is generically termed "Agroforestry". As Agroforestry continues to develop as an applied science, it will find newer and newer applications. One of these is the juxtaposition of agriculture and industrial forestry. Earlier the requirements of wood-based industries were met mainly by forests and same time there was a great burden on forests for meeting the continuous growing demand for timber, fuel-wood and fodder. Sensing the danger to the ecosystem because of heavy deforestation caused by indiscriminate and injudicious cutting of trees, the government has restricted the easy access of wood-based industries to forests for their raw materials since the late eighties. Through the new forest policy of 1988, the government has advised these industries that they should meet their raw material needs by establishing a direct relationship with farmers who can grow trees on their farms. Thereafter several models of raising industrial wood for paper and pulp, plywood, pencil, matchwood etc. through agroforestry has been developed by industries and institutions leading a concept of industrial agroforestry.

Brief Review of Research Work

Chauhan *et al.* (2012) inferred that the overall growth pattern of poplar generally followed **a** rising trend with age. All the growth and biomass parameters of different age plantations differed significantly and increased up to the third year and then started declining. The mean tree height increased from 6.64 m (1st year) to 21.80 m (5th year), whereas diameter at breast neight (dbh) ranged from 5.83 to 21.38 cm. The tree height and diameter growth followed a linear trend.

Chauhan *et al.* (2011) concluded that the annual productivity of poplar was recorded maximum in fourth year (42.4 m^3/ha/yr and later the annual wood increment decreased (39.8 and 35.6 m^3/ha/yr after 5th and 6th year, respectively).

Chauhan *et al.* (2009) reported age of poplar trees is most important factor influencing wheat grain (var. PBW 343) yield. Poplar growth during second year was maximum and thereafter the growth progressed with age but at the decreasing rate. The mean monthly height and dbh were 0.58 m and 0.49 cm, respectively, during second year of planting and 0.22 m and 0.32 cm, respectively, during fourth year of planting.

Chandra (2011) studied that all the 14 clones performed better than G-48, which was commercial and mother clone. Clones selected on growth and form need testing for root ability of cuttings, pest resistance and locality trails, so that, farmers are able to get better clone in future and continue to grow poplars to enrich their economy and solve problem of shortage of wood in the country.

Devaranavadgi and Rathod (2011) revealed that genotype S-10 produced 91.11 m^3 ha^{-1}, 123.67 m^3 ha^{-1}, 163.20 m^3 ha^{-1} and 193.74 m^3 ha^{-1}in all the four years i.e., 8, 9, 10 and 11^{th} year of planting respectively, followed by K-636 and S-24. The average yield of wood increased as the years of planting increased in all the eight genotypes but the genotype S-10 obtained highest annual average wood yield of 11.39, 13.74, 16.32 and17.61 m^3 $ha^{-1}year^{-1}$ in all four years i.e., 8, 9, 10 and 11^{th} year of planting, respectively followed by S-24 and K-636.

Prasad *et al.* (2010a) concluded that in regions where annual rainfall is around 1000 mm, *Leucaena* can be planted at a spacing of 3 x 0.75m for improving intercrop performance, higher tree productivity and returns.

Srinivas and Raju (2011) found that genotype 288 produced maximum volume (334.1m^3ha^{-1}), CAI (55.91m^3ha^{-1}) and (41.81m^3ha^{-1}) followed by 6 and 286. This high yields combined with better quality of produce and lower per unit production costs have improved profitability of clonal Eucalyptus plantations substantially. Farmers can expect on an average net returns upto Rs.3, 00,000/ ha at 4 years rotation from

irrigated clonal Eucalyptus plantations assuming yield of 150 tonnes and current farm gate price of Rs.2000 per tonne for Eucalyptus logs.

Prasad *et al.* (2010b) revealed that **in** regions where annual rainfall is around 1,000 mm and soils are fairly good, *Eucalyptus* at a density of 1,666 plants per ha can be planted in uniformly spaced wide-rows (6 m) or paired rows at an inter-pair spacing of 7-11 m for improving intercrop performance without sacrificing wood production.

Vanlalngurzauva *et al.* (2010) revealed in Gamhar that the return from the crop was highest (Rs.13,800.00 $year^{-l}$) with blackgram or groundnut and cowpea (Rs. 6,180.00 ha^{-1} $year^{-1}$). Growth of Gamhar was influenced due to intercropping with legume intercrops (blackgram, groundnut and cowpea). The tree height, dbh and volume yield of gamhar was observed highest when intercropped with blackgram (8.35 m, 16.78 cm and 5.27 m^3 ha^{-1} $year^{-1}$), respectively closely followed by gamhar+groundnut intercropping (8.30 m, 16.54 cm and 5.09 m^3 ha^{-l} $year^{-l}$), respectively and lowest with Gamhar+ rice intercropping (7.34 m, 15.70 cm and 4.22 m^3 ha^{-1} year respectively.

Divya (2011) concluded that the most suitable intercrop for Casuarina clone based agroforestry system is cowpea followed by groundnut and blackgram.

Kannan *et al.* (2013) reported that at the spacing of 3 x 3 m *Melia dubia* attained average girth of 12 cm and height of 6.4 m within one year. The tree attained an average height of 8.5 m with 13.5 cm girth two year after planting with supplementary irrigation.

Tewari *et al.* (2014) concluded that *Ailanthus excelsa* can be planted in the spacing of 6m x 6m which give the highest MAI compare to 8m x 8m and 10m x 10m spacing in Agroforestry.

Kittur *et al.* (2015) revealed that spacing treatments exerted profound influence on bamboo growth. For instance, clump height decreased by 19 % in the widest (12m x 12m) bamboo spacing compared to that of the closest (4m x 4 m) spacing. However, widely spaced bamboo exhibited better clump diameter, crown coverage and crown width.

Prasad *et al.* (2012) found that timber volume and timber weight of individual trees were significantly higher with trees in Agroforestry system in *Leucaena* in comparison to farm forestry system. *In Leucaena,* the highest individual tree volume recorded at the time of harvest was in 3 x 0.75 m spacing (0.035m^3/tree) which was about 66% higher in comparison to the narrow rows. In *Eucalyptus,* tree volume and weight of the individual tree were not significantly influenced by spacing and differences between Agroforestry and farm forestry systems were not significant.

Nayak *et al.* (2014) reported that *Acacia mangium* with pineapple based agrisilvicultural system recorded the highest gross return, net return and BC12 as compared to other agrisilvicultural systems and sole crops. Therefore, *A. mangium* and pineapple based agrisilvicultural system may be preferred for rainfed uplands of Odisha.

Singh *et al.* (2014) reported that appropriate selection of tree crop combinations and the proper management and cultural practices of trees as well as crops play an important role for the success of any Agroforestry venture. Poplar can be successfully grown in riverine areas having fertile well drained soil with intensive management. But *Eucalyptus* and *Melia* can be grown on a wide range of soil and management conditions. Trees for industrial use are catching the attention of farmers. Planting of trees on farm lands will not only improve the economic and social status of farmers but also help to improve the ecological conditions of an area. Moreover, Agroforestry is considered as one of the economical viable options for crop diversification in the state.

Conclusion:

In India there is huge gap between demand and supply of raw material for wood based industries. The government forests are not in position to supply wood raw material to industries and now the option lies in farm forestry/agroforestry or imports. The empirical agroforestry models of tree crop combinations need to develop with proper temporal and spatial arrangement of trees fixing technical rotation for economic yield from farm. For cogeneration of Food and Wood we need I develop Industrial Agroforestry model by incorporating commercial tree species of superior clone with agriculture crop which are economically viable. Further for the promotion of Industrial Agroforestry we need to frame better Forward and Backward linkages

between growers/farmers and wood based industries by different contract farming model, tree insurance option and simple regulatory mechanism.

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Seminar No. 40

Speaker: **Mr. Rahul Sreekumar**	Reg. No. 2030314013
Degree: M.Sc. Forestry (Forest Genetic Resources)	Course No: FOR-591
Major Adviser: **Dr. R.P. Gunaga**	Venue: Conference Hall
Minor Adviser: **Dr. S.K. Jha**	Date: 05/11/2015

IMPROVEMENT STUDIES OF TREE BORNE OIL SEEDS IN INDIA

Biofuels are important renewable and alternate source of fossil fuels. Both National Biofuel Policy (NBP)- 2009 and National Agroforestry Policy (NAP)- 2014 play an important role in development and production of biofuels in the country. NBP (2009) targets the replacement of fossil fuels by biofuel to the

extent of 5% blending by 2012 and 20 %, both for biodiesel and bio-ethanol by 2017. NAP (2014) aims at integrated land use option for livelihood, environment and energy security through TBOs. India has very rich and diverse tree species which are scattered in different climatic zones. More than 100 diverse tree species are producing seed oil suitable for biodiesel. Non-agricultural lands like wastelands, fallow lands may be used to growing these crops; however, productive potential of biofuel can be sustainably enhanced through introduction of high yielding genotypes, resistance varieties with cultural operations and silvicultural management. As per report of the committee on development of biofuel, biodiesel requirement for 2006-07 @ 5%, 10%, 20% blending levels was 2.62, 5.24 and 10.48 million tons, respectively; whereas, proposed target for 2011-12, blended biodiesel @ 5%, 10%, 20% was 3.35, 6.69 and 13.38 million tons. To promote biodiesel in the country, biofuel policy was framed and tree improvement programme through R & D in terms of selection and multiplication of high yielding genotypes was also stressed. There are several constraints for Tree Borne Oil Seeds (TBOs), long gestation period, alternate bearing, lack of high yielding genotype, ¯eproductive problems are some among them. In the present seminar, some of the priority TBOs for cultivation and production are described along with their oil content. Short description of few TBOs pertaining to phenology, gestation period, seed yield and oil is also given. Characteristics of biodiesel of few TBOs are compared with international standard, which may be useful for breeders for further improvement. Details of NOVOD board mandate pertaining to improvement aspects of some TBOs are discussed along with country reports, report of FCRI, Mettupalayam and NAU, Naysari. Details of case studies are described below.

Brief Review of Work

Rao *et al* (2008) evaluated 32 Jatropha accessions for seed yield, 100 seed weight and oil content. Seed yield (36.60 to 263.97g plant^{-1}), hundred seed weight (56.98 to 79.09g) and oil content (29.85 to 37.05 %) varied significantly among accessions. Accessions like CRDJ1, CRDJ17, CRDJ20, CRDJ21, CRDJ23, CRDJ27, CRDJ28 and CRDJ31 performed better and resulted in more than 35% oil content. Highest broad sense heritability of more than 99% was exhibited by oil content, followed by 100 seed weight (93.16%).

Mohapatra and Panda (2010) studied the variation in seed characteristics and oil content among 20 Jatropha accessions. Among all, TNMC-2 (38.11 g), Kendrapada (37.83 g) and TFRI-2 (37.36 g) recorded the highest 100 seed weight, whereas Baramunda accession recorded maximum seed oil content (36.33%) than other accessions.

Tandel (2009) from Naysari Agricultural University, Navsari studied seed yield, seed traits and oil content among different accessions of *Jatropha curcas* for two years. Considering pooled data of two years (2007 & 2008), maximum 100 seed weight was recorded in NAUJ-6 (68.75 g). MPC-CH-B (30.32 g/plant) and TFRI-1 (33.32 %) showed superiority for seed yield per plant (g) and oil content (%), respectively.

Nayak (2006) studied the provenance variation in seed and seedling traits of *J. curcas* under nursery condition. Among seed traits, maximum 100 seed weight (69.70g) and seed length (2.40cm) were found in P3 (Rajpipla) provenance, whereas highest seed width was recorded by P_{14}- Jabalpur (1.40cm). Among seed traits, heritability value was found to be more for 100 seed weight (86.2%), followed by seed width (71.7%) and seed length (70.5%).

Divakara (2014) evaluated the variation in seed traits and oil content in 23 CPTs of *Madhuca latifolia* from Jharkhand, India. Variability studies revealed that, more than twelve accessions performed better for 100-seed weight (247.5+49.2g) and oil content (43.8+3.7%). CPT-16 recorded the maximum 100 seed weight (282.4g) and oil content (51.2%). All studied seed traits showed higher heritability values.

Wani *et al.* (2015) studied growth parameters along with seed traits in 20 CPTs of *Madhuca indica.* Among 20 CPTs, height ranged from 12.3 (S_7-Sahson and S_{11}-Gousi) to 18.3m (S_{12}-Phulpur). Maximum DBH was recorded in S18- Nawabganj (4.2m). Variation in seed length (3.0 - 3.9 cm) and seed diameter (1.4 - 1.9 cm) also recorded. Further, seed traits, germination and seedling vigour attributes were used for cluster analysis and they found total 5 clusters in which cluster IV was formed by 7 families (S3, S8, S10, S12, S13, S18, S20), followed by cluster I with 6 families (S1, S2, S5, S9, S14, S17) indicating there was a diversity among CPTs.

Rant *et al.* (2010) studied the variation in seed yield and oil content in 20 CPTs of *Pongamia pinnata* in the Konkan region of Maharashtra and reported that the seed yield (kg) and oil content (%) ranged from 10.24 to 115.12 and 31.17 to 42.00, respectively. Highest seed yield was obtained in KKVPP-13, whereas KKVPP- 17 showed maximum oil content.

Mukta *et al.* (2009) analyzed the variability for oil content in 21 germplasms of *P. pinnata.* It was found that the whole range of oil content covered from minimum of 9.5% in DORPP-98 to maximum of 46% in DORPP-49. It was concluded that two accessions with very high oil content (>43.6%) *viz.* DORPP-49 and DORPP-80 and seven genotypes (DORPP 39, *51*, 72, 76, 83, 85 and 87) having >40 % oil content were suggested for the development of high oil yielding lines.

Pavithra *et al.* (2013) studied the pod and seed characteristics among 232 CPTs of *P. pinnata* from five different agroecological zones of southern peninsular India. All the pod characters were recorded maximum in zone-3, except pod thickness which was highest in Zone-5. Similarly, in seed characters also, Zone-3 showed superiority over rest of the zones except in seed thickness and oil content, which were more in Zone-2.

Palanikumaran *et al.* (2015) undertaken variation study among 30 CPTs of *Calophyllum inophyllum* from different places in South India for seed oil content and other biochemical attributes. The oil content ranged from 35.7 (FCRICI 26) to 64.6% (FCRICI14) with overall mean of 46.4%. Out of 30 studied CPTs, 11 CPTs (FCRICI 2, FCRICI 3, FCRICI 5, FCRICI 8, FCRICI 9, FCRICI 13, FCRICI 14, FCRICI 17, FCRICI 23, FCRICI 25, FCRICI 27) had higher oil content (>46.4%) than the overall mean.

Shinde *et al.* (2012) identified 21 CPTs of *C. inophyllum* in the Konkan Maharashtra for fruit and seed characteristics as well as oil yield. They reported that most of the fruit and seed traits varied significantly among 21 CPTs. CPT no. KKVCI-13 performed better with respect to most of the fruit and seed traits, especially fruit size, fruit volume, seed size; while KKVCI-03 showed excel in more oil content. Furthermore, oil content and fruit weight showed the highest heritability values (>90%) indicating these traits may be used while selection of genotypes for further breeding programme.

Kumar and Bhan (2010) assessed seed source variation for seed traits and oil content in *Prunus armeniaca* and observed that oil content ranged from 50.05 - 57.97%, while stone length, breadth and thickness was ranged between 14.64 to 26.48 mm, 12.26 to 21.49 mm and 8.63 to 14.65 mm, respectively. Stone and kernel weight also varied among genotypes, which was ranged from 66.6 to 295.1 g and 18.2 to 68.18 g, respectively.

Mirgal *et al.* (2010) studied the characterization of fruit and seed traits in *Garcinia indica* and they tried to identify best genotypes from following four classes: a. very early, b. early, c. mid late and d. late fruiting based on their reproductive phenology. The seed weight per fruit ranged from 1.57 to 5.25 g and seed oil content ranged from 31.34 to 52.73%. Out of 21 identified CPTs, 11 CPTs belonged to early to mid-late fruiting category and they escaped from heavy rains. They promoted early bearing high yielding genotypes for cultivation in the Konkan area.

Nagwekar *et al.* (2010) identified superior genotype called *Konkan Hatis*- a bold type of *G. indica* variety and compared the fruit properties with earlier selection, *Konkan Amruta.* In most of the fruit and seed traits *viz.*, average fruit yield (250 kg), fruit length (4.22 cm), fruit width (6.29 cm), fruit circumference (20.1 cm), fruit weight (91.50gm), rind weight (5.60 g), long shelf life (18 days), *Konkan Hatis* performed better than *Konkan Amruta.* Finally, they released *Konkan Hatis* as high yielding-bold type genotype by Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.

Hareesh and Vasudeva (2010) mapped various populations of *G. indica* in Uttar Kannada district of Karnataka and studies. fruit and seed traits variation. They observed that fruits collected from Up Ghat region showed higher rind traits than coastal region, whereas for oil content, genotypes selected from coastal region resulted in higher seed oil. Further, they have made fruit descriptor for *G. indica* based on colour and shape of fruits.

Conclusion:

In a country like India, there are many plant species whose seeds remain unutilized and underutilized that can be tried for biodiesel production. Non-edible oil seeds like some TBOs are the potential feedstock

for production of biodiesel in India. These species have shown promises and fulfills various biodiesel standards. Study shows that, even though more than 10 TBO species are prioritized, many tree improvement works are confined to Jatropha and Karanja. However, improvement work on other few species such as Kokam, Mahua, Simarouba and Wild apricot is in progress. Among many aspects of tree improvement, majority of work is on identification of best seed source/ genotype, progeny trial and genotype multiplication. However, there is lack of information about breeding programme, seed orchard establishment and others. From this study, it is concluded that several institutions have released best genotypes having high seed yield, better seed quality and higher oil content in prioritized TBOs, which can be used for growing in agroforestry and conventional plantations. It is also showed that there is tremendous scope for improvement of many TBOs in India.

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Seminar No. 41

Speaker: **Mr. Ravindra Dhaka** Reg. No. 2030314014
Degree: M.Sc. Forestry (Agroforestry) Course No: FOR-591
Major Adviser: **Dr. S.K. Jha** Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga** Date: 05/11/2015

CURRENT STATUS OF PROVENANCE AND SEED SOURCE RESEARCH IN TEAK *(Tectona grandis* Linn. F.)

Teak, an important source of tropical timber, grows naturally in forests of India, Myanmar, northern Thailand, Laos and Indonesia. The natural teak bearing forests in India are the largest in the world, occupying an area of 8.9 m ha in central and peninsular region (Tewari, 1992) and 2.5 m ha of plantations in the country as whole (Anon., 2012). In India the demand for teak has increased several folds during the last five decades, resulting in extraction of trees from old plantations and from natural forests. Extraction of best teak trees from forests has resulted in the loss of good genotypes (Katwal, 2003). Therefore availability of information on the genetic variation within populations and the differentiation between populations plays a significant role in the formulation of appropriate management strategies for conservation of these valuable genetic resources and its further improvement (Milligan *et al.,* 1994). In India, quality seed production areas for teak is 6,014.34 ha under SPA and 4,572.11 ha under SO (Anon., 2012).

Brief review of research works

Jayasankar *et al.* (1999) found that among 7 provenances Parambikulam, Nilambur and Malayattur provenances consistently recorded better shoot and root growth, biomass allocation and relative growth rate, while the local provenance (Trichur) was poorest. Performance of the provenances in the field followed nursery growth patterns, confirmed that growth is under strong genetic control. Further their studies reported that, application of Mahalanobis D^2 analysis and Tocher's clustering method resolved the seven provenances into 3 clusters.

Sojan and Indira (2010) analysed the variability of 19 seed related characters in ten teak populations from Kerala, Karnataka and Tamil Nadu part of Western Ghats. Provenances were significantly different for **all** characters except for length-breadth ratio of the shell diameter and mesocarp thickness. Seed characters *like* maximum possible germination, drupe length and breadth, shell weight, drupe filling percentage and hundred drupe weight were highest in the seeds from Doddaharve and lowest in Mandagadde. The Ashambu provenance showed maximum seed viability and while the seeds from Parambikulam, Hudsa and Arienkavu showed the lowest seed viability. Apart from this they also observed highest germination for seeds collected from Konni where as it was lowest for seeds from Hudsa. Cluster analysis showed three different groups.

In a 30-year-old field trial in the coastal lowland of Tanzania (Pedersen *et al.,* 2007) observed that there was significant difference in provenances for volume/ha, volume per tree, height and diameter of dominant trees. The provenance Topslip (India) consistently proved to be outstanding in terms of growth and stem quality.

Lwin *et al.* (2010) studied teak provenance trials at BagoYoma at 7^{th} year after planting. There was a significant variation in all traits of the tested provenances and also significant correlation between growth traits and the geoclimatic factors. The results of the comparative assessment revealed that local provenances (Phyu, Bago and Pyinmana) and the southern-most provenance (Mudon) generally showed better growth performances at the BagoYoma region. Further, they found that growth was highly influenced by the most favorable annual rainfall, but declined when rainfall exceeded the maximum limits of teak 3,500 mm.

Morphological characters of the progenies obtained from three seed production areas (SPAs) and three corresponding unimproved stands (UIS) of teak was compared (Lyngdoh *et al.,* 2013) at three broad teak growing regions in the Karnataka, India. In general, seed morphological parameters and mean girth were significantly superior in SPAs compared to UISs. Seed germination percentage was also higher in seeds from

SPAs. SPAs proved important as a source of moderately improved planting material with no severe threat to the genetic diversity of future plantations.

Chaix *et al.* (2011) studied 41 genetic origins of teak, including 26 open-pollinated families from a clonal seed orchard in Ivory Coast, planted in 1997 in a replicated trial at Taliwas, Sabah, East Malaysia. The mortality rate and early measurements of height, and diameter at breast height varied substantially between treatments. The largest height and diameter values recorded after 104 months were mostly from the clonal seed orchard families, while the lower performances were mainly observed for the native provenances. Narrow sense heritabilities, assessed for the clonal seed orchard families only, increased gradually with age, reaching relatively high values, especially for height at 104 months (h^2=0.76). There were also some highly significant differences between the 41 genetic origins for six qualitative traits observed from 25 to 104 months. Overall, the clonal seed orchard families were marginally less crooked and grew more vertically than the other sources.

Monteuuis *et al.* (2011) studied 42 different genetic origins of teak comprising 26 open-pollinated families from a clonal seed orchard (CSO) planted in a replicated trial in 1997, at Luasong, Sabah, East Malaysia. The trees were measured or scored for various traits at different month age after planting. Mortality rate, height (H), diameter at breast height (DBH), volume (V), and fork height (FH) varied strongly among populations and origins. The best population means after 106 months for growth were for the CSO families. Narrow sense heritabilities for the CSO families increased gradually with age. Overall, the CSO families were also straighter, less forked, and grew more vertically than the native provenance and seed-derived sources. Such differences did not exist for flowering ability and at 106 months, the great majority of the trees of the various origins had not yet entered the flowering stage.

Goh *et al.* (2013) compared 16 families with respect to the growth performances which were derived from a clonal seed orchard (CSO) and 10 provenances of teak tested in two different sites. Both sites were located in Sabah, East Malaysia, under 2,500 mm of annual rainfall and no distinct dry season. Nearly 9 years after planting, the two classes of genetic entries showed significant differences for height and diameter at breast height (DBH) and volume for the two sites combined. The superiority of the CSO families compared with the Provenances class was more obvious in Luasong than Taliwas. The CSO families were also more prone to site interaction for height and to a lesser extent, for volume than the provenances.

Twenty SPAs of teak distributed in southern, central and northern parts of Karnataka for growth status and site quality. There was a greater variation among SPAs for phenotypic growth characters as well as site quality. The overall growth of SPAs of Madikeri zone (Southern region) was found to be superior with respect to tree height, clear bole height and DBH. SPAs belonged to Dandeli (Northern region) recorded more DBH and nearly round stem. SPAs of Yallapur seed zone showed comparatively less growth over Madikeri zone. SPA of Dandeli zone recorded the more tree volume and top height, followed by SPA of Madikeri zone. Considering site quality of different SPAs, all the studied SPAs of Karnataka are growing under relatively poor site conditions. Sixteen out of twenty SPAs, nearly 80% were growing in areas with site quality classes [V and V. Interestingly, none of the studied SPAs belonged to either class I or II (Gunaga *et al.,* 2014).

Bhat and Priya (2004) characterized three major teak provenances of the Western Ghats in India in terms of mechanical and anatomical wood properties. Within the same age of 21-year-old plantations, teak from the North Kanara provenance, generally known to display slow growth, had the lower values of static bending (modulus of rupture and modulus of elasticity) and longitudinal compressive stresses than the Malabar provenance (Nilambur). The weaker timber of North Kanara provenance was attributed to its relatively high percentage of parenchyma and low percentage of fibres in the narrower rings, probably as an adaptation to nutrient-rich soil condition. Observations of 65-year-old plantations revealed that there was a trend for bending stiffness (modulus of elasticity) and maximum stress (modulus of rupture) of the timber to be highest towards the southernmost geographic location (Konni) with a greater percentage of cell wall (with higher lignification) despite the slower growth rate and well defined ring-porosity with wider bands of earlywood parenchyma tissue. The study thus underlines the need to recognize the provenance source of variation to explain the varied growth-structure-property relationships of teak and to utilize the Indian genetic resources to the optimum in future teak improvement programmes.

Growth characteristics [stem diameter (D), tree height (H), and bole volume (V)], stress-wave velocity (SWV), and Pilodyn penetration (P) for 21 seed provenances of teak planted in Indonesia found significant

differences for all measured characteristics among provenances, indicating that these characteristics are genetically controlled. Broad-sense heritability of growth characteristics, SWV, and P were moderate. Principal component analysis revealed that seed provenances from Indonesia (Bangilan, Deling, and Randublatung) and India (Malabar and Central Province) have high scores of growth characteristics and SWV (Hidayati *et al.*, 2013).

Conclusion:

The available literatures confirm that there is large variability in teak for growth, seed, fruit and wood characters. It is essentially required to capture these variations for genetic improvement of teak since the improved seed source showed better result for all the characters studied.

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Seminar No. 42

Speaker: **Mr. Mahesh K Desai**	Reg. No. 1030313001
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. Manmohan J Dobriyal**	Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel**	Date: 05/11/2015

PROTECTED AREAS AND BIODIVERSITY CONSERVATION IN INDIA

The first national park in India was declared in 1935, now famous as the Corbett National Park. There has been a steady rise in the number of Protected Areas (PAs) (National Parks and Wildlife Sanctuaries) since independence, especially after the enactment of the Wildlife Protection Act in 1972. In 1988, there

were 54 National Parks and 372 Sanctuaries covering a total area of 109,652 sq km. By the year 2000, this number had increased to 566, covering 1,53,000 sq km, or 4.66% of India's geographical area. There are currently about 631 national parks and sanctuaries in India, encompassing 1,54, 572 sq km or 4.74% of the country's geographical area. The latest review of the Wildlife Protected Area Network document brought out by the Wildlife Institute of India, Dehradun, recommends to bring the total area under the Protected Area network to 870, totaling 1,88,764 sq km or 5.74 % of the country's geographical area. This would translate into 163 national parks covering 54,789 sq km or 1.67% and 707 sanctuaries covering 1,33,975 sq km, or 4.07 % of the countries geographical area.

Brief review of research work:

Khan (1995) stated that the tree and shrub densities in different management districts showed significant differences in density values. The tree (> 6 m) density was higher inside the National Park and Sanctuary West than in Sanctuary East. Similar trends were observed for shrubs of 2-6 m and 1-2 m. The maximum species richness and diversity was observed in Sanctuary West and decreased from west to east. Gir currently supports some 51,000 chital, 2100 Sambar, 600 Nilgai and Chinkara and 400 Chowsingha. The mean livestock density was nearly three times as high in sanctuary East compared to West.

Vyas (2004) surveyed Vansda National Park and recorded a total of 54 species of herpetofauna, including 13 species of amphibians (1 species of caecilian and 12 species of frogs) and 41 species of reptiles (1 species of turtle, 13 species of lizards and 27 species of snakes) of 41 genera belonging to 16 different families.

Yadav *et al.* (2014) assessed the change detection over the span of 21 years and given a clear indication of how things have been changing in Keoladeo National Park, especially the area under water in the park. It has been found through various studies that the dense forest has decreased from 3.2% in 1989 to 2% in 2011, the agricultural land has decreased from 30% in 1989 to 20% in 2011 and fallow land decreased from 29% in 1989 to 25% in 2011. However, increase has been observed in scrub land from 20% in 1989 to 22% in 2011, area under water from 2% in 1989 to 3% 2011, marshy area from 1.7% in 1989 to 4% in 2011 and built up area has increased from 7% in 1989 to 17% in 2011.

Kala (2005) found 60 threatened medicinal plant species during the study period out of which 54 species occurred in the sampling plots. Twenty-two percent of threatened medicinal plant species were critically endangered, 16% were endangered, and 27% were vulnerable. The density of threatened medicinal plant species varied with protected areas. The Valley of Flowers protected area had the highest number of threatened medicinal plant species.

Khan *et al.* (1997) revealed that species diversity in general is greater at low and medium altitudes. Of the total number of species in Meghalaya state, 165 *(5%)* species have very wide distributional ranges and occur at low, medium and high altitudes, 1214 (36.5%) are distributed from low to medium altitudes, and 313 (9.4%) species occur from medium to high altitudes. The remaining species have narrower altitudinal ranges: 667(20%) species occur only at low altitudes, 631(18.9%) species occur only at medium altitudes, and 341(10.2%) species are restricted to high altitude areas.

Rana and Samant (2009) stated that amongst the habitats, maximum rare and threatened species (51) were distributed in boundary and shady moist forest habitats, followed by rocky (44) dry forest and degraded (28) habitats. Other habitats showed less than 28 species. They also gave some notable native, endemic, threatened and economically important species of the prioritized habitats, communities in the forest zone and alpine zone of Manali Wildlife Sanctuary.

Mishra *et al.* (2011) revealed that a total of 117 tree species representing 85 genera and 42 families were recorded in Similipal Biosphere Reserve. The average number of species per hectare was 32.5. The number of species per genus was 1.38 and that per family was 2.79. During ecological sampling at Bhitarkanika National Park they found a total of 29 species in the tree layer representing 22 genera and 16 families within 1.2 ha area. The average number of species per hactare was 24.17. The number of species per genus was 1.32 and that per family was 1.81. They also compared the percentage frequency in five different frequency classes of the reserve taking all the tree species into account indicates a decrease in number of species in successive 20% frequency class intervals up to 100% frequency class indicating homogeneity. However,

in Bhitarkanika National Park there was a deviation in frequency class from the normal frequency class indicating the heterogeneity nature of the vegetation.

Hundal (2004) reported a great wealth of biological diversity exists in the regions and in India's wetlands and marine areas. The first census was conducted in 1972 and 1036 tigers were recorded. Starting of Project Tiger in 1973 led to an increase in the tiger population; the 1989 census recorded 2683 tigers, which led to self congratulations within Project Tiger. But the next census in 1993 recorded only 2301 tigers, a decline from four years earlier. Of these tigers, 1266 (36%) were within the boundaries of the 19 Project Tiger reserves, but to conservationists, this came as a final warning. However, in case of the state of the Indian bustard has deteriorated sharply during the last 10 years.

Jayakumar and Nair (2013) noted that species richness was maximum in SEMI (West coast tropical semi-evergreen forests; 36 species) and minimum in MONT (Southern montane wet temperate forests). Tree density had a major influence on the density of vines. Density of trees was less in monsoon forests compared to the rainforests. Density of mature trees was highest in Southern montane wet temperate forests (853 individuals ha^{-1}) where vine density was negligible whereas tree saplings were reported higher in West coast tropical evergreen forests. The twiners were the most dominant vines in majority of the vegetation types. Root climbers and grapnel climbers were totally absent in Southern tropical moist deciduous forests; Vines were rare in both Southern subtropical hill savannahs and Southern montane wet temperate forests. In all vegetation types, small vines were abundant compared to larger ones.

Kamalakanan *et al.* (2014) studied Simpson diversity in *Kappaphycus alvarezii* invaded quadrats reduced gradually during post-removal period. This reduction clearly depicted the increase in dominance of *K alvarezii* in the invaded ecosystems. Due to increase in abundance, *K alvarezii* had shifted from lower rank (9th) during pre-removal to higher rank (3rd) and subsequently attained top rank (1st) after 2009, i.e. post-removal. Consequently, dominant native species such as *Gracilaria* sp., *Gelidiella* sp., *Caulerpa* sp. and *Padina* sp. were not recorded from the *K alvarezii* invaded ecosystems and other species such as *Sargassum* sp., *Turbinaria* sp., *Halimeda* sp., *Ulva reticulata* and *Hypnea* sp. had declined considerably.

Mohanraj *et al.* (2010) recorded 40 species of gastropods at Gulf of Mannar Biosphere Reserve. Most of the species are commonly found in all the study areas except *Distorsio anus* which is found only in Vaan island. The species *Ficus ficus, Colubraria muricata, Casmaria erinaceus, Natica didyma, Nerita polita, Rapana bulbosa, Purpura rudolphi, Strombus canarium, Architectonica perspectiva, Cypraea tigris, Cymatium lotorium* and *Haustellum haustellum* were rare to Gulf of Mannar region. Among the species, *Lambis lambis* and *Trochus niloticus* are listed in scheduled list of Wildlife Protection Act.

Aparajita De (2007) studied diversity of tree, shrub and herb layer and found that the diversity values H', y and m showed and initial decrease and then increase from herb to tree layer. The $_R$ diversity values however showed a different trend. It is highest for shrub followed by herb and trees have the least diversity.

Sahu and Singh (2008) stated that lower density of lantana favours the growth of sapling, seedling and herb in lower altitude, however in case of shrub and trees higher lantana density favour the growth.

Sarkar *et al.* (2013) surveyed on the abundance of carnivores and their prey in Kalesar NP and WLS in Haryana and found that pug marks were the most common (76.3%) means of indirect evidence followed by scat (15.8%), nesting or resting sign (5.3%) and hairs (2.3%). These clearly indicate that pug-marks were the common indirect evidence of carnivores. Species wise abundance of different indirect evidence also showed similar trend. Pugmark was the most common indirect sign except fox. Like carnivore, hoofmark was the most common indirect evidence (56%) followed by pellet/dung (32%) and other (hair, rubbing sign and carcass) by 7%. Number of indirect evidence of leopard was 1.02 per km followed by Jackal (0.09/km), and both hyena and fox (0.02/km). Leopard was also the most common carnivore in Kalesar NP (1.13/ km) and Kalesar WLS (0.71/km). Interestingly, no evidence of Jackal, Hyena and Fox was found in Kalesar WLS. This clearly indicates that leopard was common in both the protected areas. Number of indirect evidence of Sambar was 0.71 per km followed by Spotted deer and Wild boar (0.37/km), Barking deer and Elephant (0.12/ km), Nilgai (0.9/ km and Chowsingha (0.03/ km). This clearly indicates that Sambar, Wild boar and Barking deer were the most common prey species widely distributed in Kalesar. In

Kalesar NP, Sambar, Spotted deer and Wild boar were most common prey species. But in Kalesar WLS, Sambar, Wild boar and Barking deer were common prey species. Among prey, Sambar, Spotted deer and Nilgai mostly preferred gentle slope while Barking deer, Chowsingha, Wild boar and Elephant preferred plain terrain. This clearly indicates that prey species mostly prefers both plain and gentle slope terrain.

Kazi (2012) found that the population of Tiger, Leopard, Sambar, Gaur, Barking deer, Nilgai, Chousinga, Wild boar and Monkey were maximum in the year 2004 and 2001 but in the year 2007 and 2010 it was reduced drastically.

Prashanth *et al.* (2013) stated that the small size gaur herd was observed more number of times as compared **to** medium and big herd.

Conclusion:

Protected areas are crucial for the conservation of terrestrial, freshwater and marine biodiversity. It also protects the flora, fauna, micro organisms, ecosystem and rights of native people and increase biodiversity by providing a safe place for increasing numbers of rare and endangered flora and fauna. Moreover, it also reduces conflicts between man and environment. Protected area networks helps to reduce biodiversity loss and provides significant contributions to global conservation efforts. . The overall review reveals that biodiversity is fetching attention not only for the betterment for the sake of flora and fauna only but the ultimate and biggest stakeholder will be human beings if such areas are imparted proper executions. The social, economic, ecological as well as political issues related to biodiversity conservation need further attention and such issues to be addressed and resolved from grass root level involving local communities dwelling in and around protected areas.

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Seminar No. 43

Speaker: **Mr. Sandip M Patel**	Reg. No. 1030313003
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. M.B. Tandel**	Venue: Conference Hall
Minor Adviser: **Dr. Manmohan J Dobriyal**	Date: 05/11/2015

PRODUCTION TECHNOLOGY OF SANDALWOOD *(Santalum album* L.)

Sandalwood *(Santalum album* **L.)** is a valuable tree associated with Indian culture. It is the second most expensive wood in the world. The heartwood of the tree is treasured for its aroma and is one of the finest natural materials for carving. Sandalwood oil is used in perfumes, cosmetics, aromatherapy and pharmaceuticals. The monopoly of sandalwood trade by the Government of Karnataka, Tamil Nadu and Kerala and its consequences have resulted in severe exploitation, pushing *S. album* into the vulnerable category of the IUCN Red List (Kumar *et al.,* 2012).The natural distribution of' sandalwood extends from 30°N to 40°S from Indonesia in the east to Juan Fernandez Islands (Chile) in the west and from Hawaiian Archipelago in the north to New Zealand in the south (Srinivasan *et al.,* 1992). It is a small to medium-sized hemiparasitic tree, distributed rather widely in India. The population are more concentrated in the southern region, especially Karnataka. Tamil Nadu and For more than 5000 years, India has been the traditional leader of sandalwood oil production for perfumery and pharmaceuticals. The aroma of the oil and the wood is esteemed by people belonging to three major religions of the world —Hinduism. Buddhism and Islam.

Brief review of Survey work:

Annapurna *et al.* (2005) revealed that the potting medium consisting of sand, soil. compost, burnt rice husk and charcoal in the ratio of 25:15:50:5:5 exhibited the best overall seedling height, shoot dry weight, root dry weight, total dry weight. root hberosity and quality index (QI) of *Samalum album* as compared to other potting media.

According to Das and Tah (2013) when seeds of sandalwood was treated with 0.05% GA3, gave higher percentage of germination at 26-40 and 27-40 days after sowing, respectively in both the nurseries. The seeds are sown in March month resulted in higher germination percentage as compared to February month.

Annapurna *et al.* (2004) stated that among the various containers, the root trainer having a size of 600 mL was optimum for most of the parameters of seedling quality including height, total dry weight, shoot dry weight and QI of *Santalum album* as compared to other size of 270 ml and 300 ml. root trainers espite the large size of poly bags (600 1500 ml.).

Annapurna *et al.* (2006) found that when seedlings of sandalwood were grown with the host *Mimosa pudica* exhibited highest growth for shoot dry weiuht. total dry weight, root : shoot ratio and QI as compared to other host plants.

Radomiljac *et al.* (1998) observed that seedlings grown with *Alternanthera nana* for 134 and 109 days in the nursery prior to field establishment had greater stem diameter, height and root dry weight. shoot dry weight over the other treatments whereas number of' connected haustoria per plant was reported maximum in 84 days in the nursery prior to field establishment.

Nagaveni *et al.* (1997) revealed that the survival percentage of sandal seedlings when inoculated with various VAM showed higher survival as compared to un-inoculated. They also found that VAM inoculated seedlings enhanced shoot fresh weight, shoot dry weight, root fresh weight and root dry weight as compared to un-inoculated.

Mohan *et al.* (1998) reported that among different VAM fungi, *Glomus faciculatum* and *G. microcarpum* most commonly distributed in the rhizosphere soils at both the stages (Seedling and Adult stage).

Anonymous (2001) concluded that the performance index of sandalwood was increased when sandalwood is grown with *Ocimom sanctum* as an annual host plant as compared to *Vigna unguiculata* and without host.

Radomiljac *et al*. (1999) stated that when sandalwood was grown with *Sesbania formosa* tile superior nitrogen fixing host promoted shoot dry weight of *S. album* (g plant^{-1}), shoot dry weight increment of *S. album* (g plant) and shoot dry weight increment of *S. album* per unit dry weight of host shoot as compared to other host plants and without host plant. Whereas. *Eucalyptus camadulensis* indicating that poor hosts may suppress parasite growth.

Radomiljac *et al.* (1998) observed that *Alternanthera nana* as a host plant significantly increased *S. album* survival, height and diameter as compared to other host plant.

Shoba Rai (1990) reported in her pot culture studies that a host plant of *Casuarina equisetifolia* increased height, stem biomass, root biomass and total biomass of *S. album* seedlings as compared to other host plants with highest number of haustorical connections.

Radomiljac (1998) found that an application of liquid fertiliser Wuxal® suspension calcium (16 % N, 17.2 % Ca, 1.8 % Mg, 0.08 % B, 0.0016 % Mo, 0.0006 % Co. 0.064 % Cu, 0.08 % Fe, 0.16% Mn and 0.032 % Zn) at 0.5% (v/v) in 100 ml of distilled water on 28 April 1993 and 25 May 1993 siunificantly enhanced *S. album* survival, height, diameter and post host survival percentage.

Kamala and Angadi (1997) noted different deficiency symptoms of the trace elements Copper, Zinc, Manganese, Molybdenum and Boron in three months old sandal seedlings grown in sand culture in controlled conditions. An application of individual trace elements to the sandal seedlings grown normally in a medium of sand, red earth and compost manure increased growth and uptake of nitrogen. phosphorus and potassium.

According to the Rocha *et al.* (2014) status of leaf nutrient contents were higher in sandal tree with host plant as compared to sandal tree without host plant.

Brand *et al*. (2003) revealed that planting of *A. saligna* as an initial host. together with *A. accuminata* as a long term host, may be a suitable combination to improve sandal growth rate.

Bele *et al*. (2012) concluded that among various media experimented MSD.5Td (MS + 1.0mgl^{-1} 2,4D + TDZ) supported maximum direct somatic embryogenesis, indirect somatic embryogenesis and mean number of somatic embryo(s) per explant, whereas culture medium MS2D.5Td (MS + 2.0mgl 2,4-D + 0.5mg1^{-1} TDZ) promoted indirect organogenesis. Inoculation medium MS2Td.5N (MS + 2.0mg1^{-1} 1 1)7 + 0.5 mgi' NAA) proved superior for direct organogenesis and regeneration of plantlets via direct organogenesis. MS medium fortified with 2.0 mg1^{-1} TDZ and 1.0 mg1^{-1} GA_3 proved superior for plant regeneration via somatic embryogenesis while regeneration medium MSTd.5GA.5N (MS 1.0 mg.1^{-1} TDZ+ 0.5 mg1^{-1} GA3 +0.5 NAA) regenerated plantlets via indirect organogenesis.

Janarthanam *et al.* (2012) found maximum number of shoots on Murashige and Skoog (MS) basal medium supplemented with 1.0 mg/ L TDZ showed better growth response (80%) and produced (52.3 ± 2.1) small shootlets per explant with an average length of 2.9 ± 0.05 cm after 45 days of culture. Ihe cluster of small shootlets were cultured on same media with 10% coconut milk (CoM) showed shoot elongation up to 4.63 ± 0.4 cm. Rooting of shoots was achieved on half strength MS medium supplemented with 0.5 mg L indole-3- acetic acid (IAA) produced (6.0 ± 1.0) roots with an average height of 4.9 ± 0.2 cm after 40 days of culture. The *in vitro* raised plantlets were successfully acclimatized first under culture room condition, then to green house with 70 % survival rate.

Kumar *et al.* (2012) sorted sandalwood billets of various classes numbers from 1 to 18 which are the trade names of each class described with their price in lakhs per metric tonne of wood. The wood of Class I, II Ghotla and Ghatbadla have maximum price i.e. Rs. 41.0 lakh per metric tonne of wood.

Shoba Rai (1990) gave an idea of sandalwood growth. The heartwood formation in sandal starts around 10 to 13 years of age.

Jain *et al.* (2007) observed that sandal may occur naturally in Rajasthan where it was mainly distributed in the semi arid areas of South and East in natural forests, Agricultural lands, Old Havelies etc. The oil content in these trees of Rajasthan varied between 1.08 to 2.44 %.

Conclusion:

The potting medium consisting of sand, soil, compost, burnt rice husk and charcoal in the ratio of 25:15:50:5:5, seeds treated with 0.05 % GA3 and root trainer having a size of 600 mL increased growth parameters and seedling quality. The host plant is necessary for good growth of Sandal. The plants of leguminous family or the trees that fix atmospheric nitrogen are most suitable host. The suitable host plants are *Mimosa pudica, Alternanthera nana, Ocimum sanctum, Sesbania formosa, Casuarina equisetifolia* and *A. saligna* for successful plantation of Sandal. The seedlings inoculated with various VAM showed higher survival as compared to un-inoculated. An application of liquid fertiliser Wuxal® suspension calcium (16 % N, 17.2 % Ca, 1.8 % Mg, 0.08 % B. 0.0016 °A) Mo, 0.0006 % Co, 0.064 % Cu, 0.08 % Fe, 0.16 % Mn and 0.032 % Zn) at 0.5% (v/v) in 100 ml of distilled water on April and May months significantly enhanced survival, height, diameter and post host survival percentage and trace elements *viz.*, Copper, Zinc, Manganese, Molybdenum and Boron also essential for good initial growth when seeds are grown in sand. The *in vitro* regeneration can he done by cultured leaf disc and internodal explants tbr production of healthy ,true to type and abundant plantlets at a lesser time.

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Seminar No.44

Speaker: **Mr. Huse Santoshkumar A.** Reg. No. 1030313005
Degree: Ph.D Forestry (Forest Genetic Resources) Course No: FOR-691
Major Adviser:**Dr. R.P. Gunaga** Venue: Conference Hall
Minor Adviser: **Dr. Manmohan J Dobriyal** Date: 05/12/2015

IMPLICATIONS OF ECOPHYSIOLOGY TOWARDS GROWTH AND PRODUCTIVITY OF FOREST TREE SPECIES

Although a great deal of information concerning the physiology of trees has been accumulated, physiology has made a smaller contribution to forestry than it should. The physiological processes of trees are the machinery through which the genetic potential and the environment operate to determine the quantity and quality of growth. Actual wood production usually is far below the genetic and physiological potential because important physiological processes are often influenced by environmental factors such as drought, mineral deficiencies, unfavorable temperatures, and air pollution. The general objective of forestry is to grow trees efficiently, but to do this, foresters must understand how trees grow, and this requires some understanding of tree physiology. Thus physiology in relation to the respective sets of ecological conditions *i.e.* ecophysiology, should occupy a central position in the forestry and since the physiological processes are the machinery through which heredity and environment operate. In this study, emphasis has been given to highlight the various aspects of the ecophysiological studies of trees crops and review pertaining to ecophysiological processes and their iimplications towards growth and productivity of forest tree species are discussed below.

Brief review of literature:

Huse *et al.* (2011) studied clonal variation for growth and physiological parameters on 23 arborescent willow clones and observed significant differences for leaf display (195.00-291.00 days) and leaf area (3.41-26.45 cm^2). The check clone T23 (Kashmiri willow) had higher (291.00) leaf display than all remaining test clones and minimum (195.00) leaf display was registered for the clone T12. Among the test clones, highest (283.00) leaf display was recorded for T8 which was at par with T3 (277.00). The leaf area varied significantly with the highest value (26.45) in T21 and the minimum (3.41) in T6. Clone T18 (24.81), T20 (24.07) and check clone T23 (Kashmiri willow) (21.33) were found statistically at par with T21 (26.45).

Ceulemans *et al.* (1996) compared three fast growing tree species *viz.*, eucalyptus, poplar and willows with particular reference to growth modelling approach. In this paper, the authors reviewed the variation in the Leaf Area Index (LAI). Amongst these, maximum LAI (6.1-9.4) was observed for five irrigated poplar clones of two years age and minimum LAI (2.3) for controlled eucalyptus trial at Central Portugal of 2-10 years of age. Whereas, maximum LAI among eucalyptus was observed for well controlled, fertilized Eucalyptus of 1-3 year age with LAI 4-6.

Huse *et al.* (2008) studied clonal variations for three physiological parameters *viz.*, photosynthesis, transpiration and water use efficiency in willow clones. The range of mean values of photosynthesis (3.08-16.51, mean 8.77), transpiration (1.92-9.09, mean 5.22) and water use efficiency (1.17-3.08, mean 1.77) were recorded among 23 clones. The same clonal materials were also studied for their growth performance and it was observed that the clone T14 with better WUE gained maximum biomass (483.23 g/plant) after the first growth period.

Singh *et al.* (2012) studied variation in leaf morphology in 78 juvenile Salix clones collected from twelve different countries and observed tremendous variations in leaf length (range: 6.20-17.30, mean: 13.19 cm), leaf breadth (range: 0.88- 4.58, Mean:2.64 cm), leaf area (3.90- 66.22, mean:31.99) and leaf petiole length (0.04-2.07, mean:1.05 cm).

Ceulemans and Isebrands (1996) have reported the average photosynthetic capacity (*A* max) (µ $mol.mol^{-1}$ CO_2) and dark respiration rates (Rd) (µ $mol.mol^{-1}$ CO_2) values reported by various authors for different *Populus* species and hybrids, viz; *P. deltoids,P. maximowiczii, P. nigra, P. tremula, P. tremuloides, P.trichocarpa, P. ×euramericana, P. nigra x P. maximowiczii, P. trichocarpa x P. Balsamifera, P. trichocarpa x P. deltoids.*

Maximum value for photosynthetic capacity (*A* max) was recorded for *P. trichocarpa* x *P. deltoids* (23.25) and minimum for *P. tremula* (1.3). In case of dark respiration rates (Rd) (µ mol.mol^{-1} CO_2) maximum value (2.5) was recorded for *P. ×euramericana* and minimum value (0.1) for *P. maximowiczii*.

Ceulemans and isebrands (1996) have reported the average photosynthetic capacity (A max) (µ mol.mol-1 CO2) and dark respiration rates (Rd) (µ mol.mol-1 CO2) values reported by various authors for different *Populus* species and hybrids, viz; *P. deltoids,P. maximowiczii, P. nigra, P. tremula, P. tremuloides, P.trichocarpa, P. ×euramericana, P. nigra x P. maximowiczii, P. trichocarpa x P. Balsamifera, P. trichocarpa x P. deltoids*. Maximum value for photosynthetic capacity (A max) was recorded for *P. trichocarpa x P. deltoids* (23.25) and minimum for *P. tremula* (1.3). In case of dark respiration rates (Rd) (µ mol.mol^{-1} CO_2) maximum value was recorded for *P. × euramericana* (2.5) and minimum vale for *P. maximowiczii* (0.1).

Reddy and Naole (2009) studied the effects of canopy management on fruit yield in *Jatropha curcas*. They observed that the pruned 2 year old plant yielded 0.75 to 1.50 kg of seeds as compared to the 0.10-0.25 kg yield of unprunned plant. This gives an idea of the beneficial effect of biomass partitioning, *i.e.* from stem/branch wood to reproductive growth in Jatropha.

Davidson (1995) studied the water used by different plants including some tree species and reported that Eucalyptus used 510 liters of water to produce 1 kg. of harvested biomass. Whereas other trees *viz*., *Acacias*, conifers and *Pongamia* used 860, 1000 and 1300 liters of water to produce 1 kg of harvested biomass, respectively. The same author also discussed the uptake and removal of nutrients at harvest in *Eucalyptus* and other crops.

Conclusion:

Investigation of differences in physiological processes *viz.*, leaf development, photosynthesis to respiration ratio, allocation of photosynthate, root turnover, WUE(*i*), NUE, resistance and tolerance to various stress, among species and seed sources may be identified for better planting in specific environment. This may also help in selection of parents for future breeding programmes. Instead of simply planting a species over a large area without consideration of local environmental conditions, selection of strains with special physiological characteristics that adapt themselves to particular environmental conditions through Multi-location trials will ensure the success of the growth and productivity. Overall review showed that the better cooperation among forest geneticists, silviculturists, and physiologists in identifying the physiological limitations to growth and in finding remedies for them is essential.

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Seminar No. 45

Speaker: **Mr. Nongmaithem Raju Singh** Reg. No. 1030314003
Degree: Ph.D Forestry (Agroforestry) Course No: FOR-691
Major Adviser: **Dr. A. Arunachalam** Venue: Conference Hall
Minor Adviser: **Dr. Manmohan J Dobriyal** Date: 05/11/2015

VALUATION OF ECOSYSTEM SERVICES OF FOREST

Forests are multifunctional ecosystems which provide both ecological and economic security with provision of goods and services (MEA, 2005). Millennium Ecosystem Assessment (2005), highlighting the dependence of humans on ecosystems, and stressed the need to better describe, quantify and value (ecologically, culturally and economically) the ecosystem goods and services. Ecosystem Services (ES) have a value to society but to date no relevant market exists where these values are expressed (Zhongmin *et al.* 2003). Costanza *et al.* (1997) identified 17 types of ES across various ecosystem types, including 14 derived from forest ecosystems, and estimated the current economic value of the ES provided by the Earth's ecosystems to be at least US $33 trillion/year.

Brief Review

Pearce and Pearce (2001) summarized the various valuation methods which can be employed in valuation of forest goods and services. Among the various valuation methods choice modeling methods out weight the other methods and which can be applied for all the forest ecosystem goods and services valuation. They also estimated the economic value of forest by forest type *viz.*, tropical and temperate forests. Particularly in tropical forest the highest value was assessed in montane tropical forest in terms of both direct and indirect benefits. Similarly, in case of temperate forest, the highest value was estimated in broadleaf temperate forest. The value of indirect benefits was estimated higher than direct benefits in both forest types. Other than this, they also summarized the tourism values for tropical forested areas and found this value for different tropical forested areas ranges from $1 /ha to $740/ha.

Costanza *et al.* (1997) estimated the economic value of 17 ecosystem services for 16 biomes, based on published studies and a few original calculations. For the entire biosphere, the value (most of which is outside the market) is estimated to be in the range of US $16-54 trillion per year, with an average of US $33 trillion per year. Out of this the total value of forest ecosystem goods and services is US $4.7 trillion annually and the total annual values of all tropical and temperate/boreal forests are US $3.8 trillion and US $894 billion, respectively. Nearly 75% of total value of forests in their study was due to climatic regulation, waste treatments and food production.

Ninan and Inoue (2013) assessed the average global value of annual forest ecosystem services. The total value per ha of total forest, tropical and temperate /boreal ecosystem goods and services are US $1430, US $2950 and US $443, respectively.

Pant *et al.* (2012) studied the total economic value of the forest-based ecosystem services from the three districts, namely, Taplejung, Panchthar, and Ilam, and estimated the service value NPR 8.9 billion per year (approximately USD 125 million), equivalent to NPR 30,000 per hectare per year. The estimated value from carbon sequestration to the global community was NPR 1.65 billion. The estimate did not include cultural services. The major value was from the provisioning services, especially biomass for animal husbandry which contributed close to 60% of the total.

Krieger (2012) estimated the economic value of forest ecosystem goods and services in the United States. Climate regulation services have valued the maximum as compared to other services provided by the forest. Also he summarized the carbon sequestration values of forests.

Cabrera *et aL* (1998) assessed the economic value of estuarine, the Terminos Lagoon, Campeche, Mexico. They estimated the economic benefits for some direct uses and ecological services in the area using

group of valuation techniques. The values of mangrove ES services range between US $1,193 ha/year for water filtering service and US $1.02 ha/year for value of the rea as a critical habitat for threatened species.

Bahugana and Bisht (2013) estimated the total value of the goods and services as provided by the Indian forests and the value of Rs. 6.96 laths crore or Rs. 6968.23 billion (US$ 126.96 billion) per year. Out of this, tangible benefits accounted to 43.78 % and intangible benefits accounted to 56.22 %. These figures were the bare minimum approximate values of goods and services generated by the forests, which may even be higher if actual assessment was made.

Das (1980) estimated the environmental benefits derived from a medium sized tree of 50 tonnes during its 50 years life span, excluding values of timber, fruit and flowers. The value for single tree were assessed for following parameters *viz.,* oxygen production, conservation of animal protein, control of soil erosion, recycling of water and control of humidity, shelter for birds, squirrels, insects and control of air pollution. The highest value was assessed for control of air pollution and lowest in conservation of animal protein with overall total of Rs. 15.70 Lakh. He also estimated the value for tropical and sub-tropical forest as Rs.141.30 lath/ha and Rs.128.74 lakh/ha, respectively.

Ashwath *et al.* (2012) estimated the total value of provisioning goods and services in different scenario of Uttara Kannada Forest Vegetation. NTFP was the major contributor to the total value. The share of the value of food, medicinal plants, fuel wood, fodder, *etc* varies from 14% in Scenario Ito 8% in Scenario-IV. These goods have an important bearing on the livelihood of people and especially the livelihood of local people.

Gera *et al.* (2008) carried out a study to estimate recreational benefits derived from the Valley of Flowers National Park by employing two techniques, *viz.,* Travel Cost Method (TCM) and the Contingent Valuation Method (CVM). Application of TCM estimated a recreational value of Rs. 194.68 per visit and when extrapolated to the total number of visitors, the total recreational benefits of Rs. 5, 88, 332 were obtained. While, the value estimated by CVM gave an average willingness to pay of Rs. 1833.83 and this when extrapolated to the total number of visitors became Rs. 55, 41, 834.

Singh (2007) assessed an annual valuation of various forest ecosystem services of Uttarakhand [values were calculated as per Costanza *et al.* (1997)]. The estimated total value was 1150 US $ /ha/ yr. He also summarized the values of ecosystem services emanating from the forests of Himalayan states. The overall total value estimated was US $ 21.20 billion. The highest value was estimated from forests of Arunachal Pradesh, followed by Jammu & Kashmir; however, it was least in Sikkim.

Verma (2008) appraised the per hectare economic values of direct and indirect benefits for forest goods and services of Himachal Pradesh during 2001-02. Total economic value of this forest was estimated to be US $ 24001.0 million. A total value for direct benefits (consumption and non-consumption benefits) was estimated to be US$ 282.15 million. The indirect benefits gave more value and it was estimated to be US $ 23718.85 million. Present value for 20 years @ 5% discount rate/ ha (US$) was also calculated and the estimated the total direct benefits, indirect benefits and total economic value of forest were, 379.92.40 US $/ha, 32697.31 US $/ha and 33077.25 US$ /ha, respectively.

Hirway and Goswami (2004) have estimated the values of mangroves in Gujarat with the total of Rs. 243, 700 /ha/ yr. Out of this, the total values of direct, indirect and non-use value were Rs. 17,600, Rs. 28,400 and Rs. 197,700 /ha/ yr, respectively

Hussian and Badola (2010) assessed the dependency of local people on the Bhitarkanika mangrove forests, East coast of India through surveyed by using structured questionnaires in 324 households from 36 villages of this area. People derived various mangroves products in the form of fuel wood, fish, timber, non-wood forest products (NWFP), *etc.* These products were estimated in terms of monetary values and fuel wood consumption fetch the highest value of US $ 88.34 household/annum followed by fish caught US $ 68.6 household/annum.

Conclusion:

It is inferred that forest ecosystem is providing various direct and indirect benefits to the human societies. Direct benefits such as timber, small wood, fuel wood, non-wood forest products *etc* and indirect benefits like nutrient cycling, climate regulation, prevention of soil erosion, biodiversity conservation, aesthetic value *etc* are the major ecosystem services served by the forest. Among various methods for valuation of forest ecosystem services e.g. Choice modeling valuation, Contingent valuation method and Market price are mostly

applied but there is wide variation in estimation. Thus there is an urgent need for a transparent, fair and acceptable universal system for valuation of forest ecosystem services for national and global studies. Earlier the focus was on valuation of direct forest ecosystem services which now shifted to indirect forest ecosystem services being their wide socioeconomic and ecological spectrum contribution. The studies concluded that climate regulation, prevention of soil erosion, and biodiversity conservation are major ecosystem services provided by forests are more valued whereas other services like recreational, aesthetic and wildlife habitat are also considered at par with the previous. Considering the fair valuation of all ecosystem services even in India the contribution of forests in GDP will be man} times than the current 1.7 %. Already Green bonus to the forested states on the basis of forest ecosystem services has been accepted in India. In present scenario of climate change at National and International level the notional economic value of forest ecosystem services is need to be accredited in national accounting and budgeting system.

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Seminar No. 46

Speaker: **Mr. Desai Mahesh K** Reg. No. 1030313001
Degree: Ph.D Forestry (Agroforestry) Course No: FOR-692
Major Adviser: **Dr. Manmohan J Dobriyal** Venue: Conference Hall
Minor Adviser: **Dr. M.B. Tandel** Date: 02/04/2016

TEAK BASED AGROFORESTRY SYSTEMS

Agroforestry refers to land management systems that integrate agricultural crops with forest crops. It is a collective term for all land use systems and practices in which woody perennials are deliberately grown on the same land management unit as crops or animals, either in some form of a spatial arrangement or in a time sequence and in which there is a significant interaction between the woody perennials and the crops or animals. Indian economy has been experiencing many challenges due to growing population pressure, increasing food, fodder and fuel needs, Natural resources degradation and climate change are affecting agriculture and allied agriculture systems. The traditional knowledge of Agroforestry has been continuously used as a means to tackle such problems of rural livelihood in India for centuries. To supplement such efforts on scientific basis many initiatives has been taken and the country has become one of the leaders in Agroforestry research and development.Teak is one of the favored agroforestry tree species by the farmers. It is planted in different models, combinations as well as in different spacements. IFGTB has developed Agroforestry models like, Agri-silvicultural models (Teak + casuarinas with agricultural crops maize, cotton, turmeric, tomato and chilly), Agri-silvi-horticulture model (Teak + coconut with 46,ticultural crops plantain, turmeric, vegetables, maize and cotton) and Silvihorticulture model (Teak-Gauva, Annona) . Under irrigated lands, silvipasture model was developed with Teak and Casuarina as tree component and Napier and Guinea as pasture components (Buvaneswaran *et al.* 2014).

Brief review of research work:

Mutanal *et al.* (2009) stated that Grain yield of arable crops was higher in 20 m alley of teak + papaya rows as compared to 10m alley of teak+ papaya. Among the four crops studied, sorghum recorded significantly higher average grain yield in sole crop as compared to FC +Teak or FC + teak with grass/ subabul either in 10 m or 20 m teak alley. Similar trend was followed by groundnut, chilli and ragi when grown with teak/teak + grass or subabul. Grain yields were significantly higher in teak+papaya as compared to teak+papaya+grass or subabul. Among the four crops, yield reduction was higher in Ragi i.e 63.11 to 65.71 per cent in 10 m and 57.98 to 70.29 per cent in 20 m spaced teak rows as compared to other crops. Average gross income was significantly higher in sole crops as compared to inclusion of teak with field crops. Trend was similar throughout the experimentation. Average gross income was in the order of groundnut > sorghum > chilli > ragi. Sole crop either in 10 m or 20 m alley followed by the same field crops with teak + papaya, teak + papaya + grass and teak + papaya + subabul.

Buvaneswaran *et al.* (2010) assessed the economics of teak based Agroforestry system and given clear indication that the income from agricultural crop (Black gram) amounted to Rs. 8,670 per ha per year. The total income from teak alone amounted to Rs. 49,800 per ha. Thus, the average annual net income from Teak+Blackgram based agroforestry system amounts to Rs. 11,128 per ha. Teak cultivation registered the B: C ratio of 1.20 and IRR of 28.70% for five year period.

Mutanal *et al.* (2002) revealed that total income was highest in groundnut + teak based agroforestry system (38,037) followed by sorghum + teak (33,607) and lowest in groundnut + teak + subabul (23,011). The net return was highest in groundnut + teak (26,585) which was followed by sorghum+teak (25,259). However B:C ratio was noted maximum in sorghum + teak (2.98) followed by groundnut + teak (2.32). The contribution percentage in total income was highest in teak followed by field crops and lowest in pasture.

Umrao *et al.* (2013) stated that application of FYM had better influence on plant height, number of leaves per plant, average weight of bulbs, number of cloves per bulb and yield of garlic under open and teak shade conditions but more yield was obtained with the application of FYM under light shade of teak trees.

Mutanal *et al.* (2000a) found that plant height, leaf area per plant, dry matter production and pod yield of groundnut were noted significantly maximum in open condition. However in case of directions all the parameters were recorded maximum in Western direction as compared to Eastern direction. Furthermore distance from the alley all the parameters under study were noted maximum in 5m distance from the alley. Similar trend of results was noted in Sorghum (Mutanal *et al.* 2000b).

Patil *et al.* (2011) concluded that significantly highest pod dry matter was recorded in teak + soybean (16.4 g/pl) as compared to teak + greengram (6.2 g/pl). Teak + soybean showed significantly higher total dry matter (22.7 g/pl) as compared to teak + greengram (9.9 g/pl). Pod dry matter and total dry matter were significantly lower at 2 m distance as compared to 4 m distance from teak alley. Among the different agroforestry treatments teak + soybean recorded significantly maximum leaf dry matter (5.0 g plant-1) and followed by teak + frenchbean (4.9 g plant-1). Whereas, teak + greengram recorded significantly minimum leaf dry matter (2.8 g plant-I). Moreover the average stem dry matter of legume was higher in sole crops as compared to agroforestry system.

Nagarajaiah *et al.* (2012) stated that the herbage yield of aloe, kalmegh, stevia, citronella, lemongrass, palmarosa and patchouli were reduced significantly under teak as compared to sole whereas yield of coleus was noted maximum under teak. They also found that relative crop yield and dry matter efficiency of medicinal and aromatic plants were noted maximum in teak + coleus system.

Rao *et al.* (2007) reported that photosynthetically active radiation differed significantly at 50 and 70 days after sowing. Photosynthetically active radiation was significantly higher on western side of teak row (0.67, 0.71 langely / min at 50 and 70 DAS, respectively). PAR was noted significantly higher at 4-5 distance from teak row (0.72, 0.75 langely/min) as compared to 0-1 distance (0.58, 0.64 langely /min at 50 and 70 DAS, respectively). Among the different agroforestry systems, PAR was reported significantly lower in groundnut with + teak + grass (0.57, 0.61 langely /min at 50 and 70 DAS, respectively), followed by teak + subabul (0.59, 0.66 langely/min at 50 and 70 DAS, respectively) and teak (0.61, 0.67 langely/min at 50 and 70 DAS respectively) as compared to sole groundnut (0.83 langley/min at 50 and 70 DAS, respectively).

Mutanal and Prabhakar (2000) revealed that pod and haulm yield of groundnut were recorded significantly maximum in sole crop as compared to different AFs. Both pod and haulm yield of groundnut were reduced significantly at 1 m distance from teak rows as compared to 5 m away from teak rows and also sole crop. Moreover, pod and haulm yield of groundnut were noted significantly maximum in western side as compared to eastern side of teak rows. The light transmission ratio were lower in groundnut + teak (65.8 to 68.9 %), groundnut + teak + grass (68.6 to 70.71 %), groundnut + teak + subabul (70.0 to 71.9 %) as compared to sole crop (100 %) throughout growing season. However in case of direction the light transmission ratio was higher in western direction as compared to eastern direction.

Sharma *et al.* (2011) found that the plant height, bole height, diameter at breast height and number of leaves per branch in teak was significantly maximum in teak + rice based AFs as compared to teak sole plantation.

Patil *et al.* (2010) stated that maize yields did not differ significantly in first four years due to slower initial growth of tress species whereas grain yield of paddy was higher in the initial three years and gradually reduced with the age of tree. The yield of paddy was recorded higher in sapota + teak and sapota + sissoo. After 11 years, the yields of fodder maize crop reduced in sapota + eucalyptus, sapota + *A. molucana* and sapota + teak. At the end of 17 years, economic analysis indicated that highest income, BCR and internal rate of return (IRR) were registered highest in AFs with teak (1,89,285, 1.67 and 23.2 %, respectively) and lowest in sapota + *casuarina equisetifolia.* The economic analysis at the end of 28 years indicated that BCR was higher in Sapota + Teak + Field crops (3.23 : 1) followed by Sapota + *A. molucana* + field crops (2.71 : 1). The teak ha: AF model is economically viable AFs.

Ali *et al.* (2011) revealed that significantly highest plant height was recorded in S_2F_2 (27.39cm) followed by S_1F_2 (19.66cm). Interaction between main plot spacing and fertilizers was found significant in poplar, the highest plant height was recorded in S_2F_2 (20.14cm) followed by S_1F_2 (18.61cm). It was also observed significant in open condition, having highest plant height in S_2F_2 (16.61cm) followed by S_1F_2 (16.55cm). Similar trend was observed for number of branches, number of leaves and collar diameter of Sarpagandha. Optimum level of spacing 45x45cm and inorganic fertilizers $N_{30}P_{40}K_{30}$kg/ha appear to the best under both conditions and *Rauvolfia serpentina* response positively as intercropped with poplar and teak.

Kumar et al. (2016) stated that *Ocimum basilicum* gave highest net returns of Rs. 103327/ha from essential oil when it was grown under sole cropping system with highest benefit cost ratio (BCR) of 2.56 comapare to teak intercropped.

Conclusion:

It is concluded that teak+papaya, teak+groundnut, teak+sorghum, teak+soybean, teak+garlic, teak+coleus, teak+rice, teak+Sarpagandha and teak+Sapota+Field crops are the suitable teak based agroforestry system with good BCR. **In** case of alley, the distance from the teak row increased, it increase yield of associated crops and it was maximum in 20 m alley. In case of direction all the growth and yield parameters increased in western direction as compared to eastern direction. The light transmission or PAR plays a significant role in associated crops growth and yield parameters. Application of FYM in teak understorey crops increased the growth and yield of crops.

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Seminar No. 47

Speaker: **Mr. R. L. Sondarva**	Reg. No. 1030314005
Degree: Ph.D. Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. M. B. Tandel**	Venue: Conference Hall
Minor Adviser: **Dr. V. M. Prajapati**	Date: 04/06/2016

PRODUCTION TECHNOLOGY OF QUALITY PLANTING MATERIAL OF *Pterocarpus santalinus*

Pterocarpus santalinus L.f commonly known as "Red sanders" is an important tree of international trade. Red sanders renowned for its characteristic timbers of exquisite colour, beauty and superlative technical qualities and ranks among finest luxury woods in the world. Wavy grained wood is used for making a musical instrument, Shamisen in Japan (Reddy and Srivasuki, 1990). Heart wood of this plant is used in the treatment of diabetes, and

also in industries such as furniture and carvings. Red pigment "santalin" is used as a colouring agent in cosmetics, pharmaceutical preparation, food stuffs, paper pulpwood, leather and in textile industries (Mulliken and Crofton, 2008). Treating bone fracture, leprosy, spider poisoning, and scorpionsting (Aslam *et al.* 1998). Since this species has been included in red list of endangered plants under the IUCN guidelines (Joseph and Abeysekara, 2004).

Pterocarpus santalinus is found in India. This species is endemic to the hills of Andhra Pradesh (Cuddapah, Chittoor, some parts of Nellore). It is also cultivated in some pockets of Karnataka and Tamil Nadu (North Arcot hills); Maharashtra, Odisha and West Bengal.

Brief review of research work:

Sankanur *et al.* (2010) observed that when pod of red sanders soaked in 40 % HCL for 25 hours recorded significantly maximum germination per cent, mean daily germination, peak value, germination value and germination rate.

Akshatha and Chandrashekar (2013) observed a significant increase in the germination percentage of seeds treated with gamma rays compared to the control. The highest germination percentage of 51% was observed in the seeds treated with 50 Gy which was almost two fold higher than the control (23%). Gamma rays imposed a significant increase in the germination speed up to 100 Gy compared to control, the highest being 0.95 in the seeds treated with 25 Gy. Irradiation treatment did not affect total shoot length but higher dose of 300 Gy declined the shoot growth. Similar to shoot, there was no significant difference in root length. A gradual increase in vigor index was noticed in the seedlings up to50 Gy and further increase was not consistent, the highest being in 50 Gy treated ones which was twofold higher than the control. Irradiation did not show any impact on leaf number. A significant two fold increases in dry weight of the plants at 10 Gy, 50 Gy and 100 Gy were noticed.

Dayanand (1988) revealed that pods harvested and sown in March on wards gave better results with respect to germination and establishment of seedlings.

Sankanur and Shivanna (2010) stated that application of 33 g of poultry manure per seedlings significantly increased seedling height, collar diameter, number of leaves, total fresh weight and total dry weight. While the maximum root length was recorded in the application of 5 g Phosphobacteria.

Sankanur *et al.* (2011) revealed that application of 33 g of poultry manure per seedlings significantly increased total dry weight of leaf, shoot and root, absolute growth rate and Dickson's quality index. While the maximum Sturdiness quotient was recorded in the application of 5 g Phosphobacteria.

Venkataramaih and Swamy (1981) found that GA_3 treatment proved successful in inducing the overall elongation of the stem by increasing intermodal length whereas number of leaves was recorded maximum in control. GA_3 application also enhanced the net productivity and gross productivity.

Anuradha and Pullaiah (1999) revealed that a medium supplemented with 3 mg/l BAP + 1 mg/l NAA induced the highest numbers of multiple shoots per explant (10-15 % frequency). The nature of response varied with each treatment and a certain degree of rooting was also noticed on media supplemented with KN + BAP (2 mg/l each), NAA + BAP (1 mg/l each). Vigorously growing 8-9 multiple shoots per explant were observed at 2 and 3% sucrose levels. Coconut milk at four concentrations produced vigorous growth, but did not produce shoot regeneration except for two shoots in a few cultures. Of the four concentrations tested, 10% coconut milk produced greatest number of branches at the tip of the shoot.

Rajeswari and Paliwal (2008) concluded that among the various cytokinins tested, BAP induced the maximum response in cotyledonary nodes, whereas in leaf nodes, Kn was found to be superior to other cytokinins (BAP and 2-iP) and shoot length was found to be significantly higher in MS medium supplemented with 10 µM 2-iP compared to other cytokinins. The cotyledonary nodes showed significantly higher shoot multiplication rate and shoot length than leaf nodes on MS medium with 2.5 µM BAP and 2 µM 2-iP after first subculture. For rooting, dipping of microshoots in 5 µM IAA solution proved superior to other in vitro methods.

Vipranarayana *et al.* (2012) observed that *in vitro* seed germination of 90 % along with healthy growth was achieved on full strength MS +2.0 µM GA_3. Effect of various cytokinins and auxins on multiple shoot induction from cotyledonary node was achieved maximum in growth regulator concentration of BA 1.0 mg/l in terms of regeneration percentage, mean number of shoots/explants and mean shoot length as compared with rest of the growth regulator concentration. Treatment of micro shoots with 1500 ppm IBA for 5 min resulted

in best rooting response (85%) and induced maximum number (4.6 ±0.12) of roots per shoot after 4 weeks of transplantation to potting mixture.

Prakash *et al.* (2006) found that sprouting percentage and shoot length were reported maximum in BA 4.4 µM. The 2.2 µM thidiazuron (TDZ) was found to be the most suitable growth regulator for obtaining the highest percentage of nodal segment sprouting (74%), the number of secondary shoots per primary shoot (two or three), the shoot length (5.6 cm), the number of new nodal segments generated per active explant (4.9), and the multiplication coefficient (3.5) within 6 weeks. At the end of the sixth passage, about 90% of nodal explants produced five or six healthy green shoots, each being about 6.6 cm long with six or seven nodes. Multiplication coefficient was also increased from the first subculture (5.4) to the sixth subculture (8.3). The best rooting response was achieved on solidified half-strength MS medium supplemented with 4.9mM indole-3-butyric acid (IBA).

Padmalatha and Prasad (2008) observed nodal explants cultured on combination of TDZ and BAP showed maximum shoot which was followed by MS medium supplemented with 3.0 mg/l BAP and 3.0 mg/l KN. They also found that seed explants cultured on MS medium fortified with 2.0 mg/l and 1.0 mg/l BAP gave maximum number of shoots, nodes and higher shoot length.

Chaturani *et.al* (2006) stated that storage time of pods showed a significant effect on *in-vitro* germination of seeds. Seed germination decreased with increasing period of storage. The highest germination (96 %) was recorded for seeds extracted from pods, stored only for one week with time taken to germinate seeds of 8 days. Germination percentage was significantly higher (92%) in Anderson medium without charcoal, and low germination percentages of 62, 62 and 61 % were recorded on seeds cultured on woody plant medium (with charcoal), MS and Vitis medium (without charcoal), respectively. Seeds cultured on Anderson, Vitis and woody plant medium took almost similar time (6-8 days) for germination. Seeds cultured on Vitis medium (with charcoal) showed the longest hypocotyls length, 13.8 mm. The highest plant height and highest number of nodes per seedling were recorded for seedlings in woody plant medium while MS medium showed the lowest number of nodes and lowest plant height. Leaf formation was best in woody plant medium, and the average leaf diameter is 10.8 mm**.**

Conclusion :

Pterocarpus santalinus is valuable tree species of India. Looking to the demand and its export value it is essential to develop a scientific approach for production technology. Numerous techniques *viz.*, seed treatment with HCL (40%), Gamma radiation (50 Gy), Sowing time (March onwards), poultry manure (33 g poultry manure) and GA_3 treatments significant response to germination, morphophysiological and growth parameters of *Pterocarpus santalinus*. However, exploitation of tissue culture techniques is very promising for the production of quality planting material in short span of time to mitigate the market demand of the *Pterocarpus santalinus.*

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Seminar No.48

Speaker: **Mr. J. B. Bhusara**	Reg. No. 1030314001
Degree: Ph.D. Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. Manmohan J Dobriyal**	Venue: Conference Hall
Minor Adviser: **Dr. N.S. Thakur**	Date: 04/06/2016

CARBON SEQUESTRATION POTENTIAL OF PLANTATIONS AND AGROFORESTRY SYSTEMS IN INDIA

The concentration of carbon dioxide (CO_2) and other GHGs in the atmosphere has considerably increased over the last century and is set to rise further. Since 1750, atmospheric CO_2 concentration has risen by 30 % with a steep increase observed during last 50 years (IPCC 2001). So, there is a growing international scientific, political, administrative and social concern to develop ways to slow down the addition of GHGs to the atmosphere *viz.* 1. Efficient utilization of energy through fossil fuel combustion. 2. Use of low- carbon and carbon free fuels/technologies 3.Economical and practically feasible options or alternative for carbon sequestration. Trees serve as an important means of capturing and storing atmospheric carbon (C) in vegetation, soil, and biomass product. The United Nations framework convention on climate change(UNFCC) has recognized the importance of plantation forestry a tool for green house gas mitigation option as a need to monitor, preserve and enhance terrestrial carbon stock (Updegraff *et al.* 2004). Due to fast growth and better silvicultural practices and management, plantation forestry has an edge over natural forests while Agroforestry systems have

the potential to address complex multiple problems, to deliver multifarious benefits; potential to limit carbon emission and increase sequestration of the carbon (Rao *et al.,* 2007).

Brief review of research work:

a) Plantation

Gera *et al.* (2006) reported maximum carbon sequestration potential in Runagar district of Punjab for poplar block plantation followed Eucalyptus bund planting and poplar bund planting. Both poplar block and Eucalyptus bund weighted average of 2.96 t C ha^{-1} for the whole mitigation scenario of 25 years.

Singh and Lodhiyal (2009) observed that 8-year-old *Populus deltoides* plantation stored 78.68 % (bole wood, bole bark, branch, twigs, leaf) carbon in the above ground and 21.32 % (stump root, lateral root, fine root) carbon was allocated in the below ground components of trees.

Chauhan *et al.* (2009) studied that maximum C storage in *Acrocarpus fraxinifolius* plantation (11.26 t ha^{-1}) and minimum in the *Syzygium cumini* plantation (2.16 t ha^{-1}) out of 12 tree species at plantation level.

Madhusudanan (2010) observed that among 4 species studied, the aboveground C sequestration potential was found maximum in *Albizia procera (*189.93 Mg ha^{-1}) and minimum in *Gmelina arborea* (19.25 Mg ha^{-1}) after 20 years of age.

Nath and Das (2011) found that the carbon was recorded maximum in *Bambusa cacharensis* and it is in the order of *Bambusa cacharensis, B.vulgeris* and *B. balcooa*.

Kanime *et al*. (2013) found out of seven tree based systems carbon stocks ranged from 4.51 Mg ha^{-1} in *Populus deltoides* boundary plantation to 43.39 Mg ha^{-1} in *Dalbergia sissoo* block plantation.

Arul and Karthick (2013) found that total organic carbon sequestered by mix species plantation and Eucalyptus plantation was 27.72 and 22.25 t ha^{-1} respectively.

Sreejesh *et al.* (2013) recorded that carbon content of wood portion was 292.49 kg, bark around 18.99 kg, branches 77.09 kg while the roots contained 76.44 kg carbon per tree of teak at the age of 50 year.

Surywanshi *et al.* (2014) observed that *Moringa olifera* was sequestrated 15.775 t/tree of carbon by *Azadirachta indica* 12.272 t/tree, whereas *Eucalyptus citriodora* has lowest carbon sequestration potential 1.814 t/tree.

Singh and Singh (2015) compared the percentage carbon content and found highest in leaf part of all horticulture and silvicuture tree species, and it ranged between 44.28 % and 47.39 %. *Colophospermum mopane* tree showed highest carbon content in all parts whereas it was lowest in root (40.43 %) of *Ailanthus excelsa* trees. Average C content across all parts ranged from 45.84 % in *Colophospermum mopane* tree to 43.61 % in *Ailanthus excelsa* tree.

b) Agroforestry Systems

Kaur *et al.* (2002) compared the different system and found that *Acacia nilotica* + *Desmostachya bipinnata* system was highest carbon sequestration potential and lowest in the *Dalbergia sissoo* + *Sporobolous* combination.

Swamy and Puri (2005) explained that the *Gmelina arborea* + Wheat (9.89 Mg $ha^{-1)}$ Agrisilviculture systems sequestered more carbon as compared to other systems.

Chauhan *et al.*(2010) found that the highest carbon stock was recorded in the system in 7^{th} yr (35.10 t ha^{-1}) and lowest in the 1^{st} year and the crop carbon and yield declaimed with advancement of age of poplar tree.

Yadava (2010) found that C sequestration was maximum in the *Poplus deltoides* + wheat (31.86 t/ha^{-1}) system and minimum in the *Poplus deltoides* + wheat (Boundary plantation) (10.29 t ha^{-1}).

Rizvi *et al.* (2011) studied the carbon stock ranged from 27 to 32 t ha^{-1} in boundary plantation and 66 to 83 t ha^{-1} in agrisilvculture systems at rotation period of 7 years in the district respectively.

Kumar *et al.* (2012) compared the carbon in traditional agroforestry systems and concluded that among the all AF system highest carbon stock was in 57.45 t ha^{-1} in village Chamdaare and lowest (19.85 t ha^{-1}) in the village Manjakot. The value of total carbon in other villages was 34.98 t ha^{-1} in Budadali, 31.47 t ha^{-1} in Dungripanth, 30.64 t ha^{-1} in Keshu and 20.94 t ha^{-1} in Manao.

Prasad *et al.* (2012) reported that *Leucaena* is sequestered more carbon stock of 62.05 Mg C ha^{-1} whereas in eucalyptus farm forestry 34.43 Mg C $ha^{-1}$for rotation of 4 year with compare to the agroforestry systems

Kumar *et al.* (2012) inferred that carbon sequestration potential of silvopastoral was 10 times higher than the natural grass land and followed by agrihortisilviculture, agrisilviculture, hortipasture andagrihorticulture .

Panchal (2013) found that forest tree species sequestered higher C (t/ha) with maximum by *Eucalyptus* under AFS (*Eucalytptus* + *Hymenocallis littoralis*). Among intercrops sugarcane under AFS (Teak + sugarcane) sequestered higher above, below ground and total carbon. Among seven agroforestry system types, highest C (tonnes per hectare) was sequestered by AFS (*Eucalyptus* + *Hymenocallis littoralis*) in Navsari district of Gujarat.

Mangalassery *et al.* (2014) found that among 8 various land use systems, maximum carbon was sequestered by *Acacia nilotica* + *Cenchrus ciliaris* (6.28 Mg C ha^{-1}) and minimum in *Cenchrus setegerus* (1.74 Mg C ha^{-1}).

Bhalawe (2014) found that the carbon sequestration potential among the three land use systems exhibited in the trend of tree plantation land use system > agroforestry land use system >agriculture land use systems during two years observation in south Gujarat Condition.

Gayakwad (2015) recorded that the tree plantation sequestered (565.34 t/ha) more carbon than the other land use systems, but they cannot be extended to very large area due to high pressure and high demand of land for agriculture. So agroforestry systems is the better option for the biodiversity conservation and environment.

Chauhan *et al.* (2015) compared that carbon sequestration potential in block plantation with crop component was 9.24 t/ha/yr in comparison to 5.54 t ha^{-1} $year^{-1}$ in boundary plantation systems but which were higher than traditional crop rotation.

Bhusara *et al.* (2016) explained that among ten agroforestry system types, highest 25.48 C t h^{-1} (tree + intercrop) was sequestered by agrisilviculture (Teak + paddy) system and lowest was recorded in the agrihorticulture (Mango + paddy) system 1.41 C t h^{-1} in Valsad district of Gujarat.

Conclusion:

Planting of trees species in non forest land reduce pressure on forests and serve main purpose of industrial requirement with promotion of biodiversity and carbon sequestration. Block plantation of tree species had more carbon sequestration potential than the row and bund planted trees in agroforestry due to rectangularity and density of trees in the field. The more positive agroecosystem externalities are associated with agroforestry systems compared to any sole system. Agroforestry and tree plantations show significant carbon accumulation in living biomass, as well as demonstrating the potential to offer the environment service of carbon sequestration but agroforestry systems has potential to manage more ecological and economical benefits than the plantations.

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Seminar No. 49

Speaker: **Mr. Sandip M Patel**	Reg. No. 1030313003
Degree: Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. M.B. Tandel**	Venue: Conference Hall
Minor Adviser: **Dr. Manmohan J Dobriyal**	Date: 04/06/2016

ALLEY CROPPING AND ITS BENEFITS

Alley Cropping is an agroforestry practice where agricultural or horticultural crops are grown in the alley ways between widely spaced rows of woody plants. Alley Cropping can diversify farm income, increase crop production, improve landscape aesthetics, enhance wildlife habitat and provide protection and conservation benefits to crops. By combining annual and perennial crops that yield multiple products and profits at different times, a landowner can use available space, time and resources more effectively. Alley Cropping can be used for other purposes such as short-rotation woody crops of fast growing woody species that are combined with forage or row crops to produce fuelwood and fodder. Plantings to enhance wildlife and pollinator habitat also can be designed using appropriate species.

Brief Review of literature:

Juo *et al.* (1994) revealed that the alley of different tree species reduced soil loss from one cropping season and maximum reduction was obtained by planting of Leucaena alley 2m eroded Alfisol from gneiss (Southwestern Nigeria) as compared to tilled control.

Kang *et al.* (1990) stated that *Leucaena leucocephala* gave higher biomass of leaves and twigs (7.4 t/ha/year) and nutrient content of leaves and twigs N :247, P: 19, K:185, Ca : 98 and Mg:16 kg/ha/year as compared to *Gliricidia sepium.*

Kang and Wilson (1999) reported that planting of *Leucaena leucocephala* hedgerow @ 4 m inter row spacing on a degraded Alfisol in southern Nigeria gave maximum biomass (7.4 t/ha/yr) and N :246.5, P: 19.9 and K:184 kg/ha/yr while maximum Ca (104.3 kg/ha/yr) and Mg (17.6 kg/ha/yr) were noted in *Gliricidia sepium* hedgerow @ **4** m inter row spacing.

Mosango (1999) found that out of six woody leguminosae species maximum content in percentage of dry matter of Carbon and Nitrogen were noted in *Senna spectabilis.* Moreover, maximum **C/N** and L/N ratios were recorded in *Acacia mangium* and *Cajanus cajan,* respectively.

After two years of management of both the systems, Maria *et al.* (2013) concluded that application of prunings biomass of *Leucaena diversifolia* along with chemical fertilizers significantly increased pH, organic matter, phosphorus and potash content 0-20 cm soil depth as compared to control. They also observed that the larger aggregate size classes predominated over those of smaller sizes, with higher amounts of aggregates of 2 to 1 mm, 1 to 0.5 mm and from 0.5 to 0.25 mm in treated biomass of *L. diversifolia.*

Chauhan *et al.* (2014) revealed that the Leucaena based silvi-pastoral model was found highly productive as compared to control. The productivity of the system, however, varied with respect to Leucaena sources and followed the order of K -8 > K — 156 > K — 743A on green as well as dry weight basis.

Prabhukumar and Uthaykumar (2006) found that among the green manures *Sesbania aculeata* accumulated the largest amount of biomass (22.50 t/ha) while highest nitrogen accumulation was noted in *Sesbania rostrata* (146 kg/ha).

Meena (2011) noted that green fodder yield (1293.0 q/ha) was registered maximum when Hybrid Napier and Subabool was grown in the ration of 2:2 and it was noted minimum when Subabool was grown sole (567 q/ha).

Ghassali *et al.* (2011) stated that grain and straw of barley increased towards the centre between two hedgerows as compared to close to the tree.

Kang *et al.* (1981) noted that Leucaena pruning @ 5 t/ha was incorporated in soil along with application of N @ 100 kg/ha increased grain yield of maize. The Leucaena pruning incorporated in soil increased yield of maize as compared to surface mulch of Leucaena prunings.

Ghassali *et al.* (2011) concluded that mean moisture levels varied significantly with distance from the centre of hedgerows at 35 — 55 cm depth, while at the shallow depth of 5 — 10 cm, moisture did not show any significant variation with distance. There was no significant interaction with site except for moisture during March and April at depth 20 — 25 cm.

Juo *et al.* (1994) stated that alley cropping of Leucaena along with application of fertilizer increased grain yield of maize as compared to alley cropping of Leucaena without fertilizer and maize monoculture on a kaolinitic Alfisol at Ibadan, Nigeria.

Meena (2011) revealed that grain yield of Rabi sorghum was registered maximum when cutting interval was kept 1 month and roots of Leucaena was pruned.

Blair (1998) reported that as the percentage of available foliar pruning applied of Leucaena and Gliricidia was increased it increased maize yield and it was recorded maximum in 100 percentage of available foliar pruning applied (4.46 and 3.64 t DM/ha, respectively) with (68 and 86 %, respectively) yield increase over green manure-free treatment.

Singh *et al.* (1989) stated that the growth of alley cowpea and sorghum depended on their proximity to the leucaena hedgerows. Compared with the sole crop there was a reduction in yield of cowpea but a 34 - 48 % increase in yield in sorghum at the center of the alley. At the edges of the alleys the total dry matter production of both cowpea and sorghum was reduced by 70 - 80% compared to sole stands. The presence of a root barrier (+B treatment) almost completely removed this reduction in grain yield of alley cowpea. The leaf area index was also noted maximum in middle of the alley as compared to sole. They also stated that grain yield of cowpea, sorghum and castor was noted maximum in centre of the alley.

Juo *et al.* (1994) gave practices of alley cropping on small-holder farms on Alfisols and other well-drained high based-status soils in humid and sub-humid tropics against various goals.

Conclusion:

Planting of Leucaena alley @ 2 m spacing reduced soil loss from one cropping season. It also gave higher biomass of leaves and twigs; nutrient content of leaves and twigs as well as accumulation of nitrogen in to the soil. An application of prunings biomass of *Leucaena diversifolia* along with chemical fertilizers significantly increased pH, organic matter, phosphorus and potash content in 0-20 cm soil depth as compared to control. The grain and straw yield of associated crops (barley and sorghum) and leaf area index increased towards the centre between two hedgerows as compared to close to the tree. The alley

cropping of Leucaena along with application of fertilizer increased grain yield of maize. The presence of a root barrier almost completely removed reduction in grain yield of alley cowpea.

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Seminar No. 50

Speaker: **Mr. Huse Santoshkumar A**	Reg. No. 1030313005
Degree: Ph.D Forestry (Forest Genetic Resources)	Course No: FOR-692
Major Adviser: **Dr. R.P. Gunaga**	Venue: Conference Hall
Minor Adviser: **Dr. Manmohan J Dobriyal**	Date: 04/06/2016

TREE IMPROVEMENT RESEARCH ON EUCALYPTUS IN INDIA

The genus eucalyptus, originally from Australia with approximately 700 species of environmental value and 15 species of great use for commercial purpose (Ginwal, 2014) has now become the most cultivated tree of the world. Eucalypt was first planted in India around 1790 by Tipu Sultan, at Nandi hills followed by the Nilgiri hills in 1843 and later in 1856 regular plantations of *E. globulus* were raised to meet the demands for firewood (Wilson, 1973). Till the 80s the Mysore gum (Mysore hybrid- a form of *E. tereticornis)* was the most widely planted eucalyptus [representing about half of the eucalypts planted in many parts of India (Jacobs, 1981)] and is believed to be derived from one small stand of *E. tereticornis* at Nandi hills (Chaturvedi, 1976). Lack of sufficient genetic variability (Ginwal *et al.,* 2004 a, b) is one of the important reasons for low productivity of eucalypt plantations in India as compared to other countries. Considering this and the enormous demand for wood and wood products, various

government institutions and private organization have set up Eucalyptus tree improvement programmes viz; introduction and evaluation of species/provenances, selection of CPTs; Progeny testing; Establishment of seed orchards; hybridization and clonal forestry.

Brief review of research work:

1. Species and Provenance evaluation:

Chaturvedi *et al.* (1989) evaluated 58 Eucalyptus species and concluded *Eucalyptus camaldulensis* and *E. tereticornis* as best species to perform reasonably well in rainfed conditions. Out of 46 provenances of these two species no single provenance could perform consistently well in all experiment.

Singh and Prakash (2002) concluded that Petford, Emu creek, Gilbert River provenances of *E. camaldulensis* and Kennedy River of E. tereticornis were most suitable for planting in Punjab. Further they opined that introduction of seed collections of these best provenances would be necessary for improving the yield from plantations in Punjab.

Ginwal *et al.* (2004a) observed significant differences between the seed sources for growth parameters indicating existence of genetic differences and reported that Emu Creek-Petford and Laura River (QLD) provenances as best amongst eight sources for height and survival at two year age.

Ginwal *et al.* (2004b) observed significant differences between the provenances and families at 21 months age for growth parameters, field survival and provenance x site interaction. In general the north Queensland provenances viz; Walsh River and Burdekin River performed better indicating existence of significant genetic differences. The relative performance of the provenances was fairly consistent throughout test sites.

Dogra and Sharma (2005) reveled that the Laura area, Mt. Molly and Kennedy River provenances of *E. tereticornis* and Irwin Bank & Petford provenance of *E. camaldulensis* were best performer for the south west Punjab region advocated selection and multiplication of these best provenances either sexually or asexually for future plantation programme.

Varghese *et al.* (2008) observed fastest growth rate of plants at the driest site-Pudukottai in Tamil Nadu with an overall mean height of 5.68 m at 24 month age after planting, with the Queensland provenance appearing superior to others provenances and local land race. Growth was recorded poorest at the higher-rainfall Panampally site (mean height of 4.33 m) whereas the Sathyavedu site stood intermediate in mean height performance (5.20 m. Survival at 24 months). Seedling survival was excellent at Pudukkottai (95%) and Panampally (98%) and rather lower at Sathyavedu (80%).

Chandra *et al.* (1994) evaluated *E. camaldulensis* provenances at two locations observed that Emu Creek, Petford, Ervin Bank (QLD), Gibb River (WA) and and Katherine (NT)with promising growth rate.

Dhiman and Gandhi (2014) concluded that the seed source (provenance) 13022 (NW) of Caboolture, 12970 SRF 194 Herberton Range (Qld.) of *E. grandis* and 13026 South of Calliope (Qld.) of *E. saligna* yielded higher wood per unit area than that from the rest of the seed sources. The performance of seed source 13395 of *E. brassiana* was the poorest.

Sircar and Veerendra (2011) developed a computerized index scheme for selection of CPTs in *E. tereticornis* provenances and reported that the selection of best 66 trees out of 294 trees gives sufficient selection pressure allowing sufficient variation to remain in the population with better genetic gain.

2. Progeny testing, Establishment of seed orchards and production of quality seeds

Ginwal (2014) reported that the FRI as the pioneer institution in initiating hybridization programme in eucalypt species and summarized inter and intraspecific hybridization programme taken up by FRI.

Ginwal and Sharma (2007) revealed the domestication and genetic improvement of *Eucalyptus* efforts in northern India and further have also summarized the characteristics of the hybrids in comparison to their parents.

Venkatesh and Sharma (1976) observed heterotic effect in regards to the flowering precocity in a controlled *E. tereticornis X E. camaldulensis* cross.

Venkatesh and Sharma (1979) compared the controlled hybrid FRI 6: *Eucalyptus tereticornis X E. grandis* and FRI 10: *E. grandis X E. tereticornis*, the putative natural hybrid with the parental species and observed the hybrids as intermediate between parental species for most of the contrasting characters.

Kapoor and Sharma (1984) compared the hybrids with the parents for growth parameters and observed that the hybrids grew faster with mean height (8.38M), mean DBH (9.03 cm) and mean collar diameter (14.79 cm) in comparison to their parent species indicating heterosis.

Luna and Singh (2009) worked out the genetic variability in *Eucalyptus hybrid* progeny and observed high heritability values for height (0.71±0.11) and diameter (0.55+0.15) with high genetic gain (22.54 % and 19.95% respectively) indicating the characters governed by the genetic makeup of the traits.

Thakur and Sidhu (2010) studied the genetic and phenotypic variation among 18 months old Half-sib progenies of *Eucalyptus tereticornis* in progeny trial at Ludhiana and reported that maximum mean height (2.5 m) and mean collar diameter (2.20 cm) in family no. 16. The individual tree heritability for height and collar diameter was estimated 0.30 and 0.24 respectively. GCV (15.86 and 22.72) and PCV (29.10 and 46.75) were also estimated respectively for height and collar diameter.

Parveen *et al.* (2010) observed that the hybrid *E. torelliana* x *E. citriodora* showed standing volume of 0.18 m^3, 0.53 m^3 and 3.03 m^3 and yield of 16.17 m^3/ha., 33.12 m^3/ha and 82.79 m^3/ha at 7, 10 and 23 years age. They also reported that the hybrids had sustained hybrid vigour, both for growth and standing volume production, when compared with its parents even at the age of 23 years.

Kulkarni (2014) have classified the ITC Bhadrachalam clones based on four important characters viz; clear bole, high productivity, adaptability to refractory sites and disease resistance.

3. Clonal propagation, clonal evaluation:

Sivakumar (2016) summarized the tree improvement activity undertaken at IFGTB (ICFRE) Coimbatore and highlighted the efforts made by the Institute for improving the yield potential of Eucalyptus in South India. Further, the details of four camaldulensis clones released by the institute have also been presented.

Kulkarni (2006) elaborated the genetic improvement of eucalyptus at ITC, Bhadrachalam. As per the author, the company had a wide genetic base of 8 species comprising with 5 provenances of E. tereticornis [Black mount (60 CPTs), Kennedy river (5 CPTs), Mt. Molly (26 CPTs), Ruth creek (31 CPTs) and Mysore hybrid (299 CPTs)], 5 provenances of E. camaldulensis, with total 91 CPTs, 2 provenances of E. simulate (83 CPTs), 12 CPTs of E. urophylla, 2 CPTs of E. grandis, 1 CPT each of E. alba, E. pellita and E. toreliana. From this much wide genetic diversity (1000 CPTs) the company selected 107 promising clones which further have been bred (217 intraspecific and 30 interspecific crosses). - Presently the company is having 7 CSO for production of genetically improved seeds.

Kulkarni (2014) reported that the productivity of ITC-Bhadrachalam clones ranges from 20 to 58 t ha^{-1} yr^{-1}.compared to 6 to 10 t ha^{-1} yr^{-1} from seedling origin plantations. Further the yield data of 16 clones have been reported (with graphic presentation) which reveals that clone no. 6, 286 and 288 have yield potential (UB volume) more than 200 m^3/ha.

Lal *et at* (1997)studied the performance of shortlisted promising '*Bhadrachalam'* Clones of Eucalyptus under unirrigated rainfed conditions in Andhra Pradesh and reported that the eight clones of *E. tereticornis* (a,3,4,5,6,7,8 and 10) had yield potential in the range of 22-39 m^3/ha/yr followed by two clones of *E. hybrid* with productivity range of 33-33 m^3/ha/yr. However the clone no. 72 (a selection of *E. tereticornis)* was reported to be the poorest in performance. In the same paper the author has reviewed the performance of 24 clones tested at CTA 5, amongst which the clone 128 with 16 mt height and 35 cm **GBH** stood first followed by Clone no. 71 with 33 mt height and 15 cm GBH at 6^{th} year age.

Lal *et al.* (2006) studied the performance of 20eucalyptus clones for four years and observed that out of 20, nine clones could yield more than 100 M^3 per ha. at four ;tears rotation. Amongst the best clones 413 stood first with 144.913 M^3 per ha. followed by Clone no. 407 with 125.027 M per ha. yield.

Vennila *et al.* (2011) evaluated 27 clones of *E. camaldulensis, E. tereticornis* and *E. urophylla* at FCRI, Mettupalayam and reported that the clone no. EC MTP 48 yielded maximum volume index (740.65 cm^3) followed by the clone no. EC MTB 47 with volume index (540.34 cm^3) at the age of.8 months.

Huse *et* al.(2013) studied 18 eucalyptus clones at NAU, Naysari and reported the hybrid clones viz; G 283 and CPM 2135 as best amongst all with maximum estimated volume production of 167.79 M^3 per ha and 127.34 M^3 per ha after the third growth season.

Conclusion:

Tree improvement programme of eucalyptus in India can broadly be divided in three phases viz; introduction and evaluation of different species and provenance (till 80s), hybridization (mainly at FRI during 1966-1976), new introductions based on the earlier results, selection of CPTs from the provenance trials, Conversion of evaluation trials into SPA, establishment of SSO (during 90s-until 2000) as second phase followed by an era with full focus on clonal propagation. Efforts made by the scientists and foresters of various organizations viz; IFGTB, TNFD, APFD, TAFCORN, FRI, ITC, etc in identifying proper species and provenances through source-site matching have resulted in availability of more adaptable, high yielding germplasm. The same has now formed the wide genetic base for heterosis breeding. Various superior provenances of *E. camaldulensis, E. tereticornis* and *E. grandis* from Queensland are some significant outcomes which have also outperformed several of the FRI hybrids involving trees of earlier introduced provenances. Selection of best CPTs from the genetic gain trails/SSOs followed by clonal propagation exploiting maximum genetic gain has now been adopted by most of Research organization and private paper and plywood industries as a short term strategy with handsome returns. The overall tree improvement activities have resulted in significant increase in productivity of eucalyptus which was as meager as 25-30 t ha^{-1} to 60-70 t ha^{-1} in six years rotation. With the availability of the diverse genetic material and advancement in the tree breeding, biotechnology and silvicultural practices, further increase in the yield with reduced rotation can also be expected.

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Seminar No. 51

Speaker: **Mr. Nongmaithem Raju Singh**	Reg. No. 1030314005
Degree: Ph.D. Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. A. Arunachalam**	Venue: Conference Hall
Minor Adviser: **Dr. Manmohan J. Dobriyal**	Date: 04/06/2016

SOIL NUTRIENT DYNAMICS IN AGROFORESTRY SYSTEMS

Soil Nutrient Dynamics is the study of changes in nutrient status (quantity and forms) in a soil ecosystem under a given set of environment in temporal and spatial manner due to continuous biogeochemical processes operating in the system. Leaf litter and their decomposition processes accounting major role for soil improvement in agroforestry systems. The extent of nutrient return into soil depends on the tree species, management practices and the quantity and quality of litter (Yadav and Bisht, 2014). The management of organic C and nutrient pools in soil is crucial as it not only affects the plants survival and its growth but also influences its productivity. Agroforestry trees species are capable of taking up the nutrients (nutrient pumping) and water from the layers that are usually not utilized by the herbaceous crops.

Brief Review of Resarch

Sharma *et al.* (1997) studied different agroforestry stands and found the highest organic C and total N values in the forest-cardamom stand. The organic C was highest in spring season except for *Alnus*-cardamom and *Albizia*-mandarin stands which showed in autumn. While, total N was found highest during autumn in all the stands. Mandarin stand has the highest total-P, ammonium-nitrogen and nitrate-nitrogen as compared to other stands. Highest values of total-P were recorded in autumn in all agroforestry stands except the mandarin stand showed highest in spring. Ammonium-nitrogen was highest in winter in all agroforestry stands except for *Alnus*-cardamom stand where it was highest in spring.

Sharma *et al.* (2009) concluded that nutrient dynamics varied with age depending on the successional stage, which limited soil nutrient availability for plant uptake after the 20-year point. Soil nutrient contents (OC, SOM, TN, IN, TP, IP, and AP) showed increased nutrient pools in the younger stands after which time nutrient pools declined in the aging stands.

Tanjang (2005) studied the soil nutrient dynamics under traditional agroforestry system in three different sites. Soil organic C (SOC) was highest found (1.56 %) in Nirjuli. The highest value was recorded during July

except for Nirjuli the highest value was recorded during September. However, total Kjeldahl N (TKN) was highest (0.33) in Harmutty and recorded during November except Doimukh which showed maximum value during March. Available P was highest in Harmutty and Nirjuli sites particularly during winter and in Doimukh highest value was recorded during spring. SOC, TKN and available P showed decreased with increasing depth in soil of all the sites. Organic C and available P were greater in the surface soil layer (0–10 cm) in all the sites.

Tanjang (2009) observed net N and P mineralization showed pronounced seasonal changes in different three sites of arecanut based agroforestry system. The Harmutty site had greater N mineralization during the rainy season and immobilization during spring. In the other two sites, the most mineralization was during winter and least during the rainy season. Phosphorus mineralization was greater during autumn (September to November) in Doimukh and during winter in Harmutty and Nirjuli sites.

Bhuyan *et al*. (2014a) observed temporal variations in the concentrations of ammonium and nitrate (µg g^{-1}) under selected land use pattern *i.e*. agroforestry and vegetable agro-ecosystem and found maximum concentration (12.23 µg g^{-1}) of ammonium (NH_4^+ - N) and nitrate-N (NO_3^- -N) was recorded in agroforestry. Maximum NH_4^+ - N value in both systems was found during the autumn and winter period and minimum value during the spring season (agroforestry) and autumn season (vegetable agro-ecosystem). However, maximum NO_3^- -N was found during the rainy season (agroforestry) and winter period (vegetable agro-ecosystem).

Bhuyan *et al*. (2014b) observed temporal and spatial variations in soil organic carbon (%) and total nitrogen under two different land use pattern (LUP) *i.e*. agroforestry and vegetable agro-ecosystem. Maximum SOC and TKN were recorded in agroforestry system. Minimum SOC was recorded during the rainy season in both systems. In case of TKN minimum values were recorded during the spring (Vegetable AES) and rainy season (Agro-forestry) and while both SOC and TKN maximum during winter season. Soil organic carbon ranged between 0.59% and 1.85 %. Surface soil layer had significantly greater concentration than the subsurface soil depth.

Singh *et al*. (2000) observed seasonal variation in soil organic carbon and extractable P under agroforestry in arid region of Rajasthan. SOC varied significantly ($P<0.01$) with highest being in autumn (October) and lowest in summer. Considering the plots, SOC was greatest under *Colophospermum mopane* (0.211%) followed by *Hardwickia binata* (0.204%), whereas, it was significantly ($P<0.01$) lower in control (0.156%). Extractable P was significantly ($P<0.01$) higher (13.54), ranged from 4.41- 21.82 mg kg^{-1} in planted area than the control (10.16 mg kg^{-1}).The variations in available P between months and plots were significant. Pooled extractable P (three species and one control) was the highest in soil of *Hardwickia binata* followed by the soil of *Emblica officinalis*. Available P showed significant temporal variation ($P<0.01$) with maximum in summer and minimum in monsoon (crop period).

Khan (2009) observed fluctuated changes in total amount of nutrients at different time periods and found significant among the different *Eucalyptus tereticornis* based agroforestry systems during woody litter decomposition. Initially all the system *viz*., agrisilvicultural system (AS), boundary plantation (BP) and compact block (CB), showed the amount of total N, P and K increased during decomposition period. After that N and P showed decline 15 months (AS) and 9 and 12 months (BP) of decomposition period. Subsequently, the amount of total N was continuously increased till the end of decomposition. However, in compact block (CB) system the amount of total N was continuously increased throughout the decomposition. At the end of decomposition, the final total N of 0.168 %, 0.222 % and 0.163 % were recorded under AS, CB and BP system respectively. Total P subsequently decreased during 9 months of decomposition period in all the three agroforestry systems. Thereafter continuous increase was observed in total P in all three systems till the end of decomposition. However, the amount of total K was continuously declined till the end of decomposition. The final amount of total P and K was increased to 0.063 % (AS), 0.073 % (CB) and 0.059 % (BP) and 0.218 % (AS), 0.220 % (CB) and 0.219 % (BP) respectively.

Rana *et al*. (2005) compared the gradual changes in soil characters under open and agri-silvicultural system. There was a discernible change in soil organic carbon, pH, EC, ESP and available soil nutrients (N, P and K) under each of the two different conditions. However, magnitude of change was recorded greater in case of agri-silvicultural system than that of open area condition.

Sharma *et al*. (2007) reported that nutrient cycling in terms of standing state and uptake of nitrogen and phosphorus were enhanced in the stands with alder trees and achieved lower nutrient use efficiency for both

nitrogen and phosphorus. The agronomic yield (productivity) of large cardamom doubles under the influence of *Alnus* trees.

Iqbal (2013) found highest organic carbon (1.438% in 0-10 cm and average 1.063%) and total nitrogen (average 0.069%) under agroforestry system than other land use pattern (cropland, grassland and fallowland) while the lowest lowest organic carbon and total nitrogen were found under fallowland and grassland respectively.

Jamaludheen and Kumar (1999) stated average annual litter production was highest for *Acacia* (12.69 Mg ha^{-1}) and the lowest for *Pterocarpus* (3.42 Mg ha^{-1}). Other MPTs showed a decreasing trend in the order: *Casuarina* > *Artocarpus heterophyllus* >*Emblica* >*Leucaena* > *Ailanthus*> *Artocarpus hirsutus*. *Acacia, Ailanthus, Pterocarpus and Casuarina* have a distinct peak during November-February and a lean period from April to August. The total nutrient accretion of 203 kg N ha^{-1} yr^{-1}, 6 kg P ha^{-1} yr^{-1} and 15.7 kg K ha^{-1} yr^{-1} were recorded. Nutrient accretion through detritus fall also was profoundly variable among the MPTs. Decay rate was faster for all species during the first few months which correspond to the moist and warm period (May-July). Monthly decay rate coefficient (k) for the nine MPT taxa varied between 0.16 (*Acacia*) to 0.31 (*Ailanthus*) with half-lives ranging from 2.2 to 4.4 months.

Hasanuzzaman and Hossain (2015) reported that nutrient concentrations (N, P and K) showed significant ($p<0.05$) differences among dry and wet season experiment. The highest concentrations of N (55 and 40 mg/g) and P (31 and 39 mg/g) were added to the soil from the leaf litter of *Melia azadirachta* where as the highest K (70 and 74 mg/g) concentration was added to the soil from the leaf litter of *Azadirachta indica*.

Yadav *et al.* (2008) observed mean monthly litterfall was higher in *Dalbergia sissoo* followed by *Prosopis cineraria, Acacia leucophloea* and *Acacia nilotica.* Irrespective of species, the major litterfall coincided with the months between October and March, the low rainy season and low temperature months. Distinct peaks were observed in February (*D. sissoo* and *P. cineraria*) and January (*A. nilotica* and *A. leucophloea*). Irrespective of MPTs, as litter decomposition proceeds, concentration of N and P in the residual mass increased initially and then decreased. Unlike N and P, K concentration in litter decreased almost continuously as decomposition progressed. The decrease was rapid in the early stages and gradual in final stages of decomposition.

Rodrigues *et al*. (2015) found total organic carbon (TOC) concentrations was higher ($P<0.05$) in HD and MD than in LD and MC both seasons, while soil microbial biomass C (MBC) and N (MBN) showed highest values in HD and lowest under the straight grass pasture (MC) ($P<0.05$)

Kaur *et al*. (2000) found soil microbial biomass C (90.56–168.0 µg/g soil) and biomass N (13.16–35.59 µg/g soil) were maximum during the summer month of March 1996. The soil microbial biomass showed a marked decrease in July as compared to values in March and December ($p<0.01$).

Conclusion:

Agroforestry play an important role in regulating nutrient cycling and in maintaining soil fertility in agro-ecosystems. The efficiency of an agroforestry system (AFS) depends on the amount of nutrient released from components during the decomposition process along with amount and timing of the released nutrients to satisfy the needs of the components. Agroforestry systems promote more closed nutrient cycling than any other agricultural systems by uptake, recycling and synchronization. It is due to tree root (fine and coarse) architecture, litterfall rate and dynamic, decomposition rate, different nutrient released pattern and rhizosphere microbial activities. Further AFS also improves the physico-chemico and biological properties of soil and modification of microclimate to regulate diverse nutrient cycling as per different climatic and edaphic conditions. In AFS system nutrient dynamics occurs due to continuous addition of litterfall, root activities and effect on microclimate depending up on the nature of species, prevailing climatic conditions and other system controlling factors.

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ACADEMIC YEAR : 2106-17

Seminar No. 52

Speaker : **Mr. Bhagora Mayurkumar N** Reg. No. 2030315001
Degree : M.Sc. Forestry (Forest Genetic Resources) Course No: FOR-591
Major Adviser:**Dr. R.P. Gunaga** Venue : Conference Hall
Minor Adviser: **Dr. N.S. Thakur** Date: 03/09/2016

STATUS, PROBLEM AND MANAGEMENT OF TEAK SEED ORCHARDS IN INDIA

Teak, *Tectona granids* Linn.f. (Lamiaceae) is one of the important deciduous forest tree species and naturally distributed in South-east Asian countries. Teak is internationally recognized for its valuable timber with character features like grain structure, colour, strength, durability and weather-resistant qualities (Tewari, 1992). There is a great demand for best quality teak wood at national and international market. Annually about 3 million m^3 of teak wood is harvested globally (Subramanian *et al.*, 1994). On an average, 30,000 to 50,000 ha area has been annually planted with teak. It is proposed to take up another 10 million ha area under teak plantation for next five years from 2015 through Green India Mission and rehabilitation of degraded forest areas programme (Ashwani Kumar, 2014). To achieve this, about 4600 tons of quality seeds would be required. Quality of quantity of timber can be achieved through tree improvement and silvicultural interventions. Quality seeds play major role on quality and productivity of timber wood. About 10-14 per cent cumulative gain in terms of yield can be achieved through CSO and SSO approaches as compared to unimproved seed source. Genetic quality seeds are procured from seed orchards (SOs) and seed production areas (SPAs). Presently, there are 1245 ha of Clonal Seed Orchard (CSO), 393 ha of Seedling Seed Orchard (SSO) and 5541 ha of Seed Production Area (SPAs) in the country and they contribute about 311 tones of quality seeds. However, as per recent target, there is gap of 4288 tons of quality teak seeds (Katwal, 2005 and Ashwani Kumar, 2014). There are several reasons for quality and quantity of seed production in seed orchards. Details of status, problems and management of seed orchards are given below:

Brief review of research work:

Status and problems of Teak Seed Orchards

In India, teak improvement studies have been initiated from 1960s through selection of plus trees, establishment of seed orchards and seed production areas. First pilot CSO was established in Dehradun with 20 clones (Rawat *et al.*, 1992), later other teak growing states started establishing CSO from 1978 onwards. Katwal *et al.* (2003) reported 900 ha of teak CSO in the country. Presently, the total extent of CSO is increased to 1245 ha (Ashwani Kumar, 2014). Status of CSO of Karnataka, Kerala and Central India are described (Gunaga and Vasudeva, 2005; Maria Florence and Mohan Das, 2011; Rupnarayan *et al.* 2016).

It is reported that there was a poor seed yield among seed orchards established within the country (zero to 2 kg with average of 0.20 kg per ramet) as well as outside *viz.*, 0.61 kg /ramet and around 46 kg h^{-1} in Thailand, 0.1 to 0.5 kg/ramet in Indonesia and 1.7 kg/ramet in Nigeria (Bhat *et al.*, 2005 and Katwal, 2005). Low fruit production, extended juvenility/Non-flowering nature of ramet, poor seed filling and poor seed germination are major problems associated with seed orchards. All the seed orchards have been failed to produce large quantity of quality seeds and this could be due to asynchronous flowering, heavy rainfall during blooming period, reproductive constrains like floral variation, lack of pollination and pollinator activity, contribution of no seeds by non-flowering ramets, site quality and local environment, physical admixture of clones/ graft failure, drupes affected by Insect/ pest or diseases and lack of cultural management (Gunaga and Vasudeva, 2005; Indira, 2005; Varghese *et al.*, 2005). Details about consequences for low seed production and its quality have been described by case studies.

Rawat *et al.* (1992) studied the variation pattern of flowering among 20 clones. There was a great variation among clones for flowering initiation and duration. Many clones started flowering during Jul.-Aug. and some of them during Sept. Per cent of flowering (14.3 to 93.7%) and fruiting (6.7 to 90.5%) varied among clones; however, two clones did not set fruits and *Teli* clone did not bear flowers, even at maturity age.

Gunaga and Vasudeva (2002) reported that asynchronous flowering among 25 clones from clonal teak seed orchard, Karnataka. Two distinct peak flowering seasons *viz.*, 2nd fortnight of June (southern clones) and 2nd fortnight of July (northern clones) have been recorded. Clones from northern provenance flowered later than southern and central clones. They have also observed that early flowering clones have escaped from peak rainy season and later flowering clones coincided with peak flowering period. This pattern could be the major problem for low seed production.

Gunaga and Vasudeva (2009) also quantified the flowering synchrony through phenograms as well as overlap index. Phenograms showed clear pattern of asynchronous flowering in seed orchard. Further, overlap index that ranged from 0 to 1, where indicating no overlap between two clones and 1 refers to complete overlap between two clones. A higher value of the overlap index is suggestive of greater overlap. Result showed that clones from Dandeli (clone numbers 1–4) and Kulagi (clone numbers 32–34) region exhibited highest overlap among themselves (more than 0.95), Similarly, clones from Shimoga (clone numbers 13, 14, 16, 31) and Kodagu (clone numbers 17–19 and 22–24) provenances also showed higher values of overlap. However, overlap between clones from northern and southern was quite less indicating asynchronous flowering.

Gunaga *et al.* (2005) recorded significant variations among the clones for non-flowering nature at two CSOs, Manchikere and Karka. In Manchikere CSO, the range of variation for per cent non-flowering ramets was between 9.07 (MySA2) to 33.35 per cent (MyHuTl), whereas in Karka CSO, it ranged from 4.18 (MySS2) to 80.43 per cent (MyHuTl). Year to year variation for this trait was significant among clones of Karka CSO. Result showed that there was a substantial contribution of non-flowering individuals in CSO may lead to lower seed production.

Vasudeva *et al.* (2004) studied inter-clonal variation for floral traits among 8 teak clones. Significant variation for corolla tube diameter, flower diameter, stigma length and stigmatic diameter, pollen grains per stigma and fruit set per cent have been recorded. The number of pollen grains per stigma was very low, indicating a poor pollination success.

Indira (2010) studied mating system and pollen flow in teak. Result showed that only 19 per cent of the fruits brought from the population with low insect activity had seeds; while 47 per cent fruits collected from the site with large number of insects, and 32 per cent fruits from the area of moderate insect activity had seeds. Revealed the percentage of more than one-seeded fruits was also high in the plot with good insect activity. In the population having low insect activity, more than two seeded fruits were absent. This shows the active role of pollinators in fruit set as well as seed filling.

Nicodemus *et al.* (2007) recorded seed fertility variation among two CSOs in Tamil Nadu. Result showed that seed fertility was generally low in both the orchards and proportion of flowering ramets ranged from 16 to 53 per cent. Each orchard had one abundant flowering year in which 53 and 39 per cent of ramets resulted in flowering condition in CSO-I and CSO-II, respectively; however, remaining ramets did not flowered. Significant variation among clones for fruit production was recorded in both CSO-I (1-18 kg/ ha) and CSO-II (9-17 kg/ ha). Year to year variation was also recorded, where only 60 per cent of the clones flowered in all four years in both the orchards.

Mathew and Vasudeva (2003) reported significant variation for seed germination and its indices. Dormancy release pattern of individual clone was different. The overall seed germination of different clones found to be very poor. On other hand, a perfect negative association between age of the ortet (mother tree) from which the clonal material was originally derived and the per cent germination of its progeny was recorded. It indicates that care must be taken to avoid clones of older ortets while establishing future CSOs.

It is recorded that teak is a insect pollinated species (Hymenopteran, Dipteran, Coleopteran, Lepidopteran, Hemipteran and Tysonpteran) and showing self-incompatibility, where natural out crossing was only about 1 per cent; however, in the case of experimental cross pollination, selfing was only 10 to 12 per cent (Indira and Mohan Das, 2002). This clearly shows that there is a need of large number of pollinators during blooming period.

Gunaga *et al.* (2014) studied site quality and fruit yield among SPAs of teak, where most of the SPAs belonged to III to V site quality and none of the SPAs did not belonged to I and II site quality. Correlation study showed a weak positive relationship with seed yield and site quality (R^2=0.052), indicating poor site quality could

be one of the factors for low seed yield. Site quality could be one of the factors that affect the fruit yield among CSOs located at different places as seen in Nicodemus *et al.* (2007).

Seethalakshmi *et al*. (2011) assessed foliar nutrient contents of N, P, K, Ca and Mg among flowering and non-flowering clones of teak at Kerala. Flowering clones showed higher N, P, K, Ca and Mg than non-flowering during flowering and fruiting period. However, nutrient level found to be different among flowering season. There was a decrease in P and K contents in the leaves of flowered trees from the time of flowering till fruit maturation after which there was an initial increase; however, no appreciable variation in foliar nutrient status was seen in non flowered trees.

Management of Teak Seed Orchard

Gunaga and Vasudeva (2005) suggested that clonal selection to be made based on the synchrony of flowering to obtain higher quality seed yield. In order to accommodate all the selected clones, two separate CSOs (may be of two sets) may be established based on early and late flowering clones. Further, insect -pollinated tree species like teak may need some specific design such as Neighbourhood design or a systematic design, so that clones will have an opportunity to mate freely with each other and each clones have an opportunities to share pollen to recipient to get higher seed quality. They have also suggested placing beehives during blooming period in the seed orchards to improve the pollinator activity and pollination to obtain higher seed yield. Commercial bee attractants such as Bee-Q could also be used to encourage visitation of local pollinators.

Dadwal *et al.* (2013) recorded infection status of teak seed collected from different plantations and it ranged from 35 to 93 per cent infection caused by seed borers like *Dichocrosis punctiferalis*, *D. pendamalis* and *Pagyda salvalis.* Further, he also identified fungal-floral association, where 18 different fungi associated at different stages of flower and fruit development. In order to minimize damage caused by seed borer and fungi, Dadwal *et al.* (2013) undertaken an experiment in the clonal seed orchard of teak at Nandigram, Seoni, MP and total eight combination treatments such as biopestcidal spray (*Bacillus thuringiensis*, *B. amyloloquefaciens*), insecticidal spray (Monocrotophos), fungicidal spray (Bavistin), trace element (Rallis tracel-2) and growth hormone (Planofix) have been applied. Result showed that maximum number of seeds per panicle (136.5) and its seed weight (130.16) was recorded in Monocrotophos (0.05%) + Bavistin (0.2%) treatment as against control treatment (17.0 and 9.25, respectively). The insect and fungal damage was also less in this treatment. Therefore, it is suggested to apply combination of Monocrotophos (0.05%) + Bavistin (0.2%) in the month July and 2nd dose during 1st week of August in seed orchard to enhance fruit production.

Suwan *et al.* (2009) studied the effect of the different kind of pollination and pollinators activity (*Trigona collina* and *Ceratina sp*.) during peak flowering season on fruit set of teak. It is observed that a total of 6963 flowers were pollinated, 3785 from trees at 12x12 m spacing and 3178 from 6x6 m spacing in which two weeks after hand cross-pollinations, flowers from both the 12x12 m and the 6x6 m spacing showed the highest per cent fruit set (24.1 and 22.0%, respectively), followed by open- pollination (20.6 and 19.5%, respectively) and pollinations by *T. collina* (20.4 and 21.4%, respectively). The percentage of fruit set at 4 week after pollination, *T. collina*-pollinated flowers was highest (13.1 and 12.3%), followed by open-pollinated (10.0 and 6.5%), cross-pollinated (9.1 and 8.6%), *Ceratina* sp. pollinated (7.1 and 2.9%) and it was low in self-pollinated flowers (3.2 and 3.4%) in 12x12 m and 6x6 m tree spacing indicating role of pollinators on fruit production in teak.

It is observed that there are four pattern of flowering have been noticed in seed orchards such as consistently flowering, irregular flowering, regularly alternate flowering and consistently non-flowering. Srivastava *et al.* (2008) studied effect of different chemicals/ hormones on flowering and fruit yield among low and non-flowering clones. In the low flowering clones, the highest number of flower/ panicle was recorded in case of Paclobutrazol (PBZ) @ 4 g.i drench application (5064.5), which was five-folds higher than the control (923.3 flowers/ panicle). The same treatment also showed 6559.5 number of flowers per panicle in non-flowering clones. Salicyclic acid @ 2000 ppm foliar application was also increased the flowers per panicle in low flowering (1679.5) and non-flowering (2896.0) clones. These chemicals/hormones also increased the fruit yield in low and non-flowering clones, where PBZ @ 4 g.i drench application resulted in 542.5 g and 585.0 g seeds per tree in low and non flowering clones, respectively. Similarly, salicylic acid @ 2000 pap also yielded an average of 346.3g and 330.0 g of seed per tree in low-flowering and non-flowering clones, respectively and it is suggested to use these chemicals to improve seed yield in seed orchards.

Maria Florence and Mohanadas (2011) studied effect of different dose of fungicides on seed quality in teak. On the inflorescence sprayed with 0.5% of Bavistin (Carbendazim), the infection was only 19 per cent, whereas in controls (untreated), the infection was 90 per cent. Indofil (Mancozeb) at 0.5% reduced the infection up to 42 per cent; however, Saaf (Carbendazim + Mancozeb) did not show any effectiveness in controlling the infection. It is recorded that the seed setting percentage was enhanced by fungicidal application, where inflorescences sprayed with Bavistin at 0.5%, the seed filling was 50 per cent and it was 16 per cent in control. The seed setting was increased to 35 and 38% by spraying Indofil at 0.25 and 0.5 per cent concentration, respectively. It is concluded that, of the three fungicides, Bavistin consistently gave good control of fungal infection and resulted in good seed filling.

There are other silvicultural treatments such as soil working, fertilizer/ manure application, partial girdling, *etc*, which have already practiced in other tree species, can also be applied in the seed orchards to enhance seed germination.

Conclusion:

It is concluded that the main assumption of establishment of seed orchard is failed to produce sufficient quantity of quality seeds in teak. There are several problems in seed orchard, asynchronous flowering and irregular bearing, non-flowering, lack of pollination are major ones. Such problems have been noticed in almost all seed orchards of teak in the country. Different scientists worked on teak to improve the seed quality and quantity. However, some of the management practices such as placing bee hives during blooming period, application of Paclobutrazol (PBZ) @ 4 g.i drench application, spraying of Bavistin at 0.5%, application of combination of Monocrotophos (0.05%) + Bavistin (0.2%) improves the seed quality and yield for some extent. Due to asynchronous flowering among clones, scientists are suggested to go for clonal selection and proper design while establishment of seed orchard by placing clones of synchronous flowering at proper place to increase genetic quality and seed yield in teak. Overall study also shows that there is a need of further research to improve the quality seed production among teak seed orchards to achieve the present planting target.

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Seminar No. 53

Speaker : **Mr. Chaudhari Pravinbhai Adabhai**	Reg. No. 2030315002
Degree : M.Sc. Forestry (Wood Science & Technology)	Course No: FOR-591
Major Adviser: **Dr. S.K. Sinha**	Venue : Conference Hall
Minor Adviser: **Dr. N.S. Thakur**	Date: 03/09/2016

WOOD ANATOMICAL SCREENING OF DIFFERENT TREE SPECIES FOR PULP AND PAPER MAKING

Anatomical characteristics form the basis for wood utilization in pulp and paper making industry. Among anatomical properties the quality of pulp and paper depends especially on the fiber dimension, proportion and method of separation of the fibers. Fiber characteristics that influence the quality of paper are: fiber length, fiber diameter, fiber lumen width, fiber cell wall thickness, Runkel ratio, flexibility co-efficient and the relative fiber length. Beside this, dimension and proportion of other anatomical parameters like vessel and parenchyma also play a significant role in deciding the pulp and paper quality. Hardwood and softwood tree species are used in pulp and paper making. Generally paper made from hardwood species are used for printings and writings purposes whereas, softwood species are used for packaging. During the year 2015-16, domestic production of paper was estimated to be around 12.2 million tonnes in India. The demand for wood in paper industry is likely to increase to 13.2 million tonnes by 2020 (Anonymous, 2016). Therefore, there is a tremendous scope to screen more number of tree species in plantation forestry sector and utilize scientifically to increase the production and bridge the growing gap between demand and availability of pulp wood.

Brief review of research work:

Oluwafemi and Sotannde (2007) studied on relationship between fibre characteristics and pulp-sheet properties of 5 years old tree *of Leucaena leucocephala* from Nigeria and reported that mean fibre length and cell wall thickness were 0.65mm and 2.9tim respectively while, Runkel ratio, flexibility coefficient and slenderness ratio were 0.59, 0.63 and 41.61. They found that these values are of acceptable range in hardwoods for papermaking.

Malik *et al.* (2004) studied the anatomical characteristics of *Lucaena leucocephala* at Saharanpur, India and reported the mean values of various anatomical parameters like fiber length (0.96 mm), felting power (41.27), fiber percentage (64.5%), vessel percentage (8.5%), parenchyma percentage (9%), and ray percentage (18%). They found that in the wood these characters are suitable for making good quality pulp and paper.

Dutt and Tyagi (2011) investigated on the morphological characteristics of fibers from 11 species of 4 years old *Eucalyptus* from Saharanpur, India. They revealed that *Eucalyptus grandis* fibers of Saharanpur origins were comparatively longer (0.92 mm), wider (20.12µm) and also had wider lumen (14.3µm) with thin cell wall (2.80µm) than Bhadrachalam origin, especially slenderness ratio (52.68), which is directly comparable to *Pinus kesiya* (56.51). Other eucalyptus species have shorter fibres and narrow lumen with thick wall resulting to poorer flexibility coefficient, higher Runkel ratio and rigidity coefficient.

Anbu and Parthiban (2014) studied on morphological properties of eight 3 years old short rotation trees in Tamil Nadu and recorded that among short rotation trees, *Melia dubia* had longer fiber length (1022.3µm) and lowest was found in Eucalyptus clones (538.80µm). The slenderness ratio was highest in *Lucaena leucocephala* (75.32%) and flexibility coefficient in *M dubia* (73.99%). The Runkel ratio and rigidity coefficient of *P. deltoieds* were 0.35 and 0.25 respectively which is directly related to the high burst strength, tensile strength, tearing strength and folding endurance of the paper.

Saravanan *et al.* (2013) studied the radial variations of anatomical properties at five different ages in *Melia dubia* from Tamil Nadu. They reported the mean values of vessel length (276.15µm), vessel diameter (231.0µm), vessel frequency (5mm^2), ray height (381.68µm), ray width (84.73µm), ray frequency (8.80mm^2), fibre length (923.60µm), fibre diameter (25.84µm), fibre wall thickness (6.51µm) and fibre lumen width (12.82µm) of one to five years old *M dubia* wood. They found that the values of slenderness ratio, Runkel ratio and flexibility coefficient were acceptable at second and third year for good quality pulp and paper production.

Emerhi (2011) carried out a comparative study on the fibre characteristics of two *Rhizophora* species *viz., Rhizophora racemosa* and *Rhizophora harrisonii* from Nigeria. He recorded that the mean values of fibre length and Runkel ratio of *R. racemosa* tree were 1.657mm and 0.94 while, the corresponding values for *R.harrisonii* tree were 1.717mm and 0.96 respectively and recommended that these species can be used as a good material for pulp and paper making due to its appreciable and Runkel ratio that is less than one on the average.

Silsia *et al.* (2010) studied on the fibre dimension and its derived values in 7 years old *Acacia* hybrid and its parents *viz., A. mangium* and *A. auriculiformis* from Indonesia and found that *Acacia* hybrid had longer fibre (1068µm), thinner cell wall (2.51µm), lower Runkel ratio (0.37) and higher slenderness ratio (57.4) and flexibility coefficient (0.73). The Runkel ratio of *A. mangium* and *A. auriculiformis* was also recorded less than one. They concluded that fibre length and slenderness ratio could be good predictors of pulp yield and paper strength for *Acacia.*

Ates *et al* (2008) analyzed the fibre morphology of 2 years old *Paulownia elongata* wood in comparison to *Eucalyptus* and Bamboo from Turkey. They revealed that *Paulownia* wood had lower fiber length (0.83mm), higher fiber width (36.3µm) and higher lumen width (19.2µm), thicker cell wall thickness (8.6µm) and lower Runkel ratio (0.90) than *Eucalyptus* and Bamboo. So, *Paulownia elongata* can be a good species for pulp and paper making.

Sharma *et al.* (2011) investigated on the morphological characteristics of fibrous and non-fibrous cells of more than 5 years old *E. tereticornis* and *E. grandis* at Saharanpur, India. They reported that fiber dimensions of *E. grandis* namely, fiber length (920µm), fiber width (19.2µm), lumen diameter (6.67gm) and cell wall thickness (6.27µm) were higher than *E. tereticornis.* Since, *E. grandis* and *E. tereticornis* had high Runkel ratio i.e. greater than one but there slenderness ratio and Luce shape factor values were acceptable therefore, both the species may be utilized for pulp and paper making.

Azeez *et al.* (2016) compared the fibre characteristics of 12 years old *Gmelina arborea* and trunks of *Bambusa vulgaris* measuring 4.5cm in diameter from Nigeria. They revealed that bamboo fibre has a wider fibre length distribution and higher fine length content. *Gmelina* and *Bamboo* had mean fibre lengths of 783.7µm and 1358.3µm and mean fibre widths of 24.1 and 16.9[tm, resp'jetively. The Runkel ratios of the wood samples were 0.4 *(Gmelina)* and 0.9 (Bamboo) this is indicative of their suitability for paper making.

Kiaei *et al.* (2011) investigated on fiber dimensions and biometry properties of *Ailanthus altissima* in Iran. They recorded that the fibre length, diameter, lumen width, cell wall thickness, Runkel ratio, slenderness ratio and flexibility coefficient in trunk wood were 940µm, 22.8µm, 16.16µm, 3.34µm, 0.46, 42.97, 70.12% respectively, whereas for branch wood the corresponding values were 594µm, 17.81µm, 12.78µm, 2.49µm, 0.38, 35.31 and 70.70% respectively. The morphology of fibers and its fiber indices from the *A. altissima* wood is reasonably good for the purpose of paper manufacturing.

Bakhshi *et al.* (2012) studied on the fiber dimension and biometry properties of 42 years old oak wood. They reported that fibre length, fibre diameter, lumen width and cell-thickness in spring wood of oak were 1159.72 µm, 17.30 µm and 6.59µm respectively. The flexibility coefficient (0.37 %) was very low and slenderness ratio (68.21) was moderately high while, Runkel ratio (1.79) was greater than one which make it unsuitable for pulp and paper making.

Conclusion:

Wood anatomical screenings of tree species are important parameters for selecting the species for the best quality of pulp and paper making. The short rotation trees having longer fibre length, higher slenderness ratio, flexibility coefficient and lower Runkel ratio and rigidity coefficient with high proportion of fibres are deciding factors in considering the species for the high quality of pulp and paper production. Among several hardwood tree species discussed, *Eucalyptus* spp. and *Leucena leucocephala* are promising ones. Moreover, there is a need to explore more number of tree species for quality pulp and paper production based on wood anatomical screening.

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Seminar No. 54

Speaker : **Mr. Choudhari Bhurabhai Arjanbhai**	Reg. No. 2030315003
Degree : M.Sc. Forestry (Forest Genetic Resources)	Course No: FOR-591
Major Adviser: **Dr. S.K. Jha**	Venue : Conference Hall
Minor Adviser: **Dr. D.P. Patel**	Date: 01/09/2016

STATUS OF REPRODUCTIVE BIOLOGY STUDIES IN MANGROVE TREE SPECIES

Floral biology has attracted biologists since eighteenth century, the most fundamental and comprehensive observations were made by Sprengel (1793) who had successfully explained floral biology of 461 angiosperms (with 1117 illustrations) in terms of floral transformations, functions, fitness, guides, rewards and its association with pollinator resource, determining the type and efficiency of breeding systems. Contrarily, Kölreuter (1761-1766) was of the view that the beauty of flowers had nothing to do with pollination. Willdenow (1802) had supported Sprengel's view while many contemporary workers such as Goethe (1790), Meyer (1953) and Henschel (1820) rejected it and, therefore, it remained in oblivion for decades. Darwin (1888) has rebound Sprengle's philosophy. Thereafter, evolution of plant breeding systems, their efficiency and the regulatory factors

have gain enormous attention of biologists (Vogel, 1996; Richards, 1997). However, much of such works were confined to territorial species and very few addressed intertidal species such as mangroves. Limited studies have been devoted to pollination biology and mating systems in mangroves. The knowledge of these aspects is essential to provide guidance for the conservation, planning and management of mangroves.

Brief Review of Research Work:

Pandey and Pandey (2014) studied the temporal relations in the floral processes such as anther dehiscence, stigma receptivity and nectar secretion in *Aegiceras corniculatum*. They classified the floral lifespan in ten stages. The floral life is very long (21 days) and the pace of floral transformation varies with the floral process. They observed 21 types of visitors in *A. corniculatum* flower. Among them ants and bess were most frequent visitors. Significant diurnal variations in the stigma receptivity and nectar secretions influence the pollinators' availability during different periods of the day.

Aluri and Henry (2008) found that the *Ceriops decandra* and *C. tagal* have a mixed mating system with cross-pollination as the principal system and self-pollination, which is primarily vector-dependent. *Ceriops decandra* flowers have a simple pollination mechanism that is adapted for pollination by daytime foragers, *Nomia* bees and *Odynerus* wasps. In contrast, *C. tagal* flowers are generally pollinated by Flies and honey bees. For *C. Decandra*, *Nomia* spp has potential to carry higher amount of pollen whereas in C. tagal, *Apis cerana* had higher pollen carrying capacity.

Aluri (1990) examined the floral biology in relation to pollinators in five mangrove plant species of the Godavary estuaries in Southern India. Carpenter bees were the main pollinators for *C.nuga,* sunbirds for *A.ilicifolius,* flies for *A.officinalis.* The floral-architecture was so designed to operate the pollination mechanism in each of these species. No autogamy observed in *A.ilicifolius* whereas *upto 90%* autogamy observed in *A.officinalis*.

Kavita Seetharaman and Kandasamy (2011) investigated reproductive biology in *Rhizophora annamalayana* and its parents *Rhizophora mucronata* and *Rhizophora apiculata*. The duration of flower bud development varied from species to species. Pollen of *R. mucronata* was 100 % viable. Viability was 53 % in *R. apiculata*. In *R. annamalayana*, only 3% of pollen was viable. *R. mucronata* flowers offered pollen and nectar to visitors, which were mainly *Lucilia caesar* (flies, bees, ants, etc.). Pollinators of *R. annamalayana* were restricted to *Monobia quadridens, Vespa tropica* and *Ocybadistes walkeri*. *R. annamalayana* reproduced by cross-pollination.

Ghosh and Chakrabort (2012) studied on reproductive biology of three dominating mangrove species *Rhizophora mucronata, Ceriops decandra* and *Avicennia marina* from the Indian Sunderbans. A study of pollen grain viability revealed that all of them produces fairly good amounts of viable pollen grains in their natural condition. The pollens showed their maximum viability late in the morning till early noon. All the species showed out-breeding mechanism of pollination. The fruit setting percentage obtained by xenogamy was the highest and autogamy failed to show any result in all the three genera. Although *Ceriops decandra* and *Avicennia marina* showed very limited fruit set with geitonogamy, these two species can be called facultative out-crossers, while *Rhizophora* was obligate outcrosser in nature.

Aluri *et al.* (2014) found that the flowers of *Lumnitzera racemosa* are bisexual, self-compatible, self-pollinating and exhibit a mixed breeding system. Fruit set was approximately 90% due to self and cross-pollination. Pollinators include bees, wasps and butterflies. Pollen pick up efficiency was highest for *Apis dorsata* and *Apis cerana*.

Aluri *et al.* (2012) studied the reproductive biology of crypto-viviparous *Avicennia alba*, *A. marina* and *A. officinalis* (Avicenniaceae). Self-pollination occurs in all three species even without pollen vector but fruit set in this mode is negligible. Xenogamy was most prominent in all three species. All species was strictly entomophilous.

Conclusion:

In general most of the mangroves are entomophilous and favours cross pollination. However the pollinator preference may differ from species to species. Knowledge of reproductive biology in mangrove is a prerequisite to provide guidance for the conservation, planning management and essential to understand its sexual reproductive system and regeneration ecology. The successful vegetation largely depends on the reproductive

biology. Relative to number of mangroves in country, reproductive biology study is meagre. Hence much study is still needed for effective propagation, conservation and management of mangroves.

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Seminar No. 55

Speaker : **Mr. Debiprasad Rout**	Reg. No. 2030315004
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. V. M. Prajapati**	Venue : Conference Hall
Minor Adviser: **Dr. M.B. Tandel**	Date: 26/11/2016

MYCOFLORA ASSOCIATION WITH FOREST TREE SEEDS

Seed mycoflora is a generalised term for fungi associated with seeds which may or may not have the potential of causing diseases to seeds or plants. Seeds of forest trees, like those of agricultural and horticultural crops, carry a wide variety of microorganisms like bacteria, fungi and even some viruses. Among them fungal flora has proven its wide association with many tree species which have remarkable importance in several sectors. Nearly all seeds carry spores of various microscopic fungi either on the surface or within the seed. The association of fungi shows significant effect on phytopatholgy *viz*., reduced germination, poor growth and development. However, the mycoflora have potential of producing mycotoxin which has deleterious effect on both plants and human health. The biochemical composition of seeds may disturbed due to the fungal association, which affects the seed quality and quantity. The requirement of seeds has increased tremendously in recent years in view of a large number of tree species being planted under social forestry, agroforestry and farm forestry. Therefore, seed health is of important concern for producing quality seeds.

Brief review of research work:

1.Mycoflora association:

Mittal and Sharma (1981) studied the occurrence of different fungi on the seeds of *Cassia fistula* and recorded highest association of *Aspergillus niger* in blotter test method and *Penicillium canadense* in Agar plate method.

Harsh *et al.*(1994) isolated the fungi associated with pollen grains, fruits and seeds of *Tectona grandis* and found species of *Alternaria, Aspergillus, Curvularia, Fusarium, Mucor, Penicillium Rhizopus* have external and internal association with pollen, fruits and seeds.

Vijayan and Rehill (1995) studied occurrence of different fungi on the seeds of *Shorea robusta* and found highest percentage of *Schizophyllum commune* and *Aspergillus flavus* in non surface sterilized seeds and surface sterilized seeds respectively.

Borah *et al.* (2001) reported the mycoflora associated with seeds of *Leucaena lucocephala* (Lamk.) under unsterilised and surface sterilised condition and concluded *Aspergillus niger* as the most dominant fungus species.

Sahu and Agarwal (2001a) conducted an experiment to study the incidence of seed borne fungi associated with seeds of Queen's grape myrtle (*Lagerstroemia flosreginae* Retz.) and found highest incidence percentage of *Aspergillus flavus* and *Penicillium aurantiogriseum* in Blotter and PDA method respectively.

Sahu and Agarwal (2004b) studied the incidence of seed borne fungi associated with seeds of *Leucaena leucocephala* and concluded *Aspergillus niger* as the most dominant fungus species which is commonly found irrespective of the method of isolation.

Singh and Shukla (2005a) studied the mycoflora incidence of *Prunus armeniaca* in three different seasons in a year and found *Aspergillus flavus* as the dominant one among all and monsoon time is most favourable for growth of mycoflora.

Rajput *et al*. (2010) studied the percentage infection of seeds through fungi isolated from Shisham (*Dalbergia sissoo*) and cconcluded that *Fusarim solani* is the most infectious species followed by *Curvularia lunata* .

Priya and Nagaveni (2011) carried out study on seed mycoflora of selected tree species and found maximum degree of association of *Lasiodiplodia theobromae , Pestalotiopsis guepinii and Rhizopus stolonifer with Cinnamomum sulphratum , Kneme attenuata and Syzygium malabaricum respectively.*

Sheela and Nagveni (2012) performed an experiment at IWST to study the abundance percentage of fungal flora with the seeds of *Sapindus emarginatus* using Blotters and Agar plate method and found *Penicillium citrinum* to be the most abundant species followed by *Aspergillus* and *Fusarium* spp.

Anonymous (2015) worked on seed mycoflora of *Delonix regia*, *Acacia mangium* and *Adenanthera pavonina* and observed the fungus species of *Aspergillus*, *Fusarium*, *Trichoderma* and *Alternaria* as the dominant associated species.

2.Phytopathological effects

Vijayan (1990) studied the effect of metabolites of seed born fungi of *Acacia catechu* and revealed that *Aspergillus niger* is responsible for maximum reducing effect on seed germination and root shoot length.

Vijayan and Rehill (1995) conducted an experiment to know the effect of metabolites of seed borne fungi of *Shorea robusta* on root- shoot length of seedlings and found maximum effect of *Aspergillus niger* in reducing the root shoot length than the others.

Borah *et al.* (2001) worked on seed borne fungi of *Leucaena leucocephala* (Lamk.) and the effects of culture filtrates and found the species of *Aspergillus* responsible for decreased seed germination percentage and root shoot length.

Bhanumati and Rai (2007) carried out study on dominant mycoflora of *Thespesia populnea* and its effect on seed germination and seedling vigour .The pathogenicity test showed that *Fusarium verticilloides* treated seeds had the least per cent germination and vigour index compared to all other treated seeds and control.

3.Mycotoxin:

Khan and Singh (2000) studied the mycotoxin producing potential of *Aspergillus, Penicillium* and *Fusarium* spp. and found highest numbers of isolates from *Aspergillus flavus* having maximum concentration.

Singh and khan (2001) evaluated the aflatoxin producing potential of *Aspergillus flavus* isolated from medicinal seeds and found that the association of fungus with seeds of *Aegle marmelos* has the highest potential of producing mycotoxins.

Singh and Shukla (2005b) screened the mycoflora of *Shorea robusta* to evaluate its potential for producing mycotoxin and observed that *Aspergillus flavus* is capable of producing maximum percentage of toxigenic isolates than other fungi species.

4.Biochemical degradation

Singh *et al.* (1996) carried out an experiment to study the biochemical composition of healthy and infested *Jatropha curcas* seeds in two different location and observed significant degradation in biochemicals in infested seeds.

Conclusion:

The pathogenic fungi of species *Aspergillus, Alternaria, Penicillium, Curvularia, Fusarium* and *Rhizopus* are found mostly associated with the seeds of important tree species *viz. Shorea robusta, Tectona grandis, Cassia fistula, Leucaena leucocephala, Dalbergia sissoo, Sapindus emarginatus* etc. The association of fungal flora results in reduced germination percentage, shoot–root length and seedling vigour. Some species of *Aspergillus, Fusarium* and *Penicillium* have potential of producing mycotoxins *e.g.* aflatoxin, fumonisin, ochratoxin etc. They also degrade the plant biochemicals like carbohydrates, proteins etc.

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Seminar No. 56

Speaker : **Ms. Gamit Priyanka B**	Reg. No. 2030315005
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. V. M. Prajapati**	Venue : Conference Hall
Minor Adviser: **Dr. M.B. Tandel**	Date: 17/09/2016

WASTELAND DEVELOPMENT THROUGH AGROFORESTRY

Land is one of the major natural resource for plants structural support for fulfilment of their lifecycle. Due to increasing population, pressure and excessive demand of land for agricultural and non-agricultural use. The increasing demand along with absence of effective land management policy has resulted in creation of vast stretches of wastelands. For optimal utilization of available natural resources, returning disturbed lands or wastelands to an improved state in prerequisite. Reclamation of wasteland will help to use the wastelands for

productive purposes which are presently lying unused or underused. Wasteland in India is recorded 24 percent and fallow land 12.2 percent. If we not take any step for reclaim or maintain this land it is increase day by day. So for reclamation of this wasteland one the good option is agroforestry. With agroforestry farmers can get additional income with tree, crop and animal husbandry and also improve his wasteland.Wastelands are lands which due to neglect or due to degradation are not being utilized to their full potential. These can result from inherent or imposed disabilities or both, such as location, environment, chemical and physical properties, and even suffer from management conditions.

Review o Research Work:

Acharya and Kafle (2009) observed maximum soil erosion in poorly managed forest land and sloppy land as compared to well managed land. They also observed minimum soil loss (13.55-57.1 ton /year) in well managed forest land.

Das (2016) reported maximum wasteland under Underutilized /degraded notified forest land (Agri., 708.56km^2) which is 89.52 percent of total wasteland area in Sonitpur district of Assam.

Hasan and AshrafulAlam (2006) reported maximum rate of erosion in tree crops, clean weeded system (182.90 t/ha/year) and minimum rate of erosion in multistory tree gardens system (0.01 t/ha/year) in tropical forest and tree crop systems.

Mishra *et al.* (2003) study on sodic soil and reported maximum tree density (1835 ha-^{1}) in *Eucalyptus tereticornis*, whereas average height (7.3 m), GBH (2.84 m) in *Dalbargia sissoo* and crown area (37.1 m^2) in *Prosopsis juliflora* of the 9 year old plantation. They also studied chemical properties under trees and relation with corresponding barren site and concluded that different depth of soil pH and EC was improved the soil fertility planted site than barren site and total organic carbon, total N: P: K also increased in sodic soil.

Singh *et al.* (2012) reported significantly higher plant height (7.6 m), DBH (17.7 cm), crown size (5.1m) and volume (0.428m^3) in *Paulownia fortunei*. While, maximum CD (20.3cm) in *Paulownia fortune* + *Eulaliopsis binata* under silvipastoral system on degraded lands. They also reported significantly maximum biomass /clump (0.92 kg) in *Eulaliopsis binata* alone and maximum fodder yield (121.3 q/ha) in *Panicum maximum* alone treatments under silvipastoral system on degraded lands.

Saha *et al*. (2003) reported maximum dispersion ratio (0.048) in Khasi mandarin and minimum dispersion ratio (0.025) in natural forests, whereas maximum porosity percentage was recorded in natural forests.

Vityakon (2001) reported increase in soil fertility parameter in high tree density (20 trees /400 m^2) than low tree density (9 trees /400 m^2) of *Dipterocarpus obtusifolius* tree. They were also found that higher quantities of litter fall and nutrients N,P,K ,Ca, Mg were noted in the litter sampled from paddy fields of high density of *Dipterocrpus obtusifolius* in 1987and 1988.

Kanmegne and Degrande (2002) studied effects of the tree fallow on cassava and maize yield on farm trials in the humid forest zone of Camerron and registered maximum yield of maize and cassava in tree fallow than natural fallow.

Rana *et al*. (2011) recorded maximum yield (8.58 t ha $^{-1}$) in treatment 50% NPK + 50% FYM in agri-silvi-horti system than open area (7.62 t ha^{-1}) and minimum yield (3.42 t ha^{-1}) in treatment 100 % NPK (120 kg N +80kg P + 80kg K ha^{-1}) in agri silvi-horti system than open area (2.16 t ha^{-1}). They also reported that different soil characteristics were helpful in increasing soil fertility after five years of practicing Agroforestry.

Buvaneswaran *et al.* (2003) concluded that soil fertility status was increased in all tree stand than open site condition. They further registered maximum soil microflora population in above 5 cm soil depth and at the end of raining season.

Mishra *et al*. (2006) studied the average dry forage yield of grasses planted in between fodder tree species and observed that growth and yield of almost all the species of grasses were better in associated with *Leucaena leucocephala.* In the first year dry forage yield of *B. mutica* was higher as compared to *P. maximum* with all the tree species and similar trend was observed in second, third and fourth year of investigation.

Bisht *et al.* (2014) studied forage (green fodder) yield (t/ha) for two grasses under *Dalbergia sissoo* based silvipastoral system on sodic land and observed that maximum grasses in rainy season as compared to other season and average green herbage yield of *Pennisetum purpureum* was found maximum (33.6-45.5 t/ha, average 40-54 t/ha) followed by *Brachiaria mutica (*19.4-28.9 t/ha).

Lahiri (1992) studied average yield obtained from grass and legume fodder in various area of lateritic zone with tree species like *Eucalyptus, Acacia auriculiformis, Sesbania grandiflora, Leuceana leucocephala* (spacing 4m × 1.5m) and observed maximum fodder yield (250, 200, 180 Quintal/ha/year) in *Pennisetum pedicellatum* than other species.

Gupta *et al*. (1984) observed maximum soil loss in bare soil (without shelterbelt) (546.8 kg/ha) and minimum soil loss in *Cassia siamea - Albizia lebbek* (184.3 kg/ha) of different types of shelterbelts. They were observed maximum nutrients loss due to wind erosion in bare soil as compared to other types of shelterbelts. They were also revealed that three row of pealmillet as shelterbelt has increased the yield of cowpea and lady's finger crops in order of 21 and 44 percent over unsheltered crop in summer season under shifting sand dunes land.

Conclusion:

The planting of trees on wasteland/barren site not only reduced soil erosion but also increased fertility status of soil and microflora of upper surface. The introduction of Agroforestry system in wasteland increases availability of fodder in dry period and also improves fertility status of soil after decomposition of leaf litter. The silvipastoral and Agri-silvi-horti system based on *Prosopis juliflora, Paulownia fortunei, Eulaliopsis binata, Dipterocarpus obtusifolius, Dalbergia sissoo* and *Leuceana laucocephala* is practiced for development of wasteland.

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Seminar No. 57

Speaker : **Mr. Soufil S. Malek**	Reg. No. 2030315006
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. Manmohan J Dobriyal**	Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 17/09/2016

MEDICINAL PLANT (MEDICULTURE) BASED AGROFORESTRY RESEARCH IN INDIA

A large number of people in developing countries have traditionally depended on products derived from plants, especially from forests, for curing human and livestock ailments. With the advancement of human civilisation and increase in demand for medicinal plants leads their over extraction from the forest leaving now domestication the only alternative to meet their requirements. Mediculture agroforestry is one such approach where farmer be able to cultivate medicinal trees or herbs with the other agricultural crops and trees. About

12.5% of the 422000 plant species documented worldwide are reported to have medicinal values (Rao *et al.*, 2004); but only a few are known to be in cultivation. Since many of the medicinal plants (MPs) are grown under forest cover and are shade tolerant, agroforestry offers a convenient strategy for promoting their cultivation to ensure their regular supply as well as for conservation. In silvo-medicinal system several approaches are feasible viz. integrating shade tolerant MPs as lower strata species in multistrata systems; cultivating short cycle MPs as intercrops in existing stands of plantation tree-crops and new forest plantations as mediculture agroforestry. In India medicinal plants research carried by ICAR- DMAPR, SAUS, CSIR-CIMAP and various other institutes but medicinal plants based agroforestry research is trend of recent advancements in agriculture.

Brief review of research work:

Pujar *et al.* (2007) studied performance of medicinal plants as intercrops with teak, compared to their respective sole crops. There was reduction in fresh weight and dry weight per plant of all crops (except Coleus) indicating competitive effect of teak. Whereas, in case of Coleus, fresh and dry weight per plant was increased to the tune of 28.20 and 43.18 per cent respectively, indicating its compatibility with teak.

Nayak *et al.* (2014) conducted an experiment on economics and yield performance of some short duration fruit and medicinal crops under agrisilvicultural system in rainfed upland of Odisha, and revealed that yield of pineapple under Mangium found maximum (9981 kg/ha) while Kalmegh yield minimum (826 kg/ha). The fresh leaf yield of Aloevera under agrisilvicultural system was significantly higher (8635 kg/ha) than open condition (7095 kg/ha). Pineapple and Aloevera yield more under trees than open condition.

Dhiman and Gandhi (2011) carried out study to explore the cultivation of medicinal herb *Ammi majus* in poplar based agroforestry, and reported that the growth attributes viz. plant height, number of shoots/plant, straw yield have been affected by the age of the trees, and shown significantly lower values for these parameters under thick shade of old aged poplar. Plant height was significantly lower under 6 year old plantation (1.63 m) than 2 year old plantation (2.03 m) and open condition (2.31m). The non significant differences in plant height between open condition and 2 year old plantation indicate that the medicinal herb can tolerate partial shade

Thakur and Dutt (2007) conducted an experiment on cultivation of medicinal herbs namely *Ocimum sanctum, Spilanthes acmella, Tagetes minuta* and *Withania somnifera* in poplar based agroforestry. The higher yield reduction relative to the sole crops was obtained when grown nearer to the tree row (up to 1m distance). The presence of poplar trees were not adversely affect herbs yield between 1-2 m distance from the tree row, especially under spacing of 8m x 3m and 6m x 4m. Herbs yield reduce under closer poplar spacing (5m x 5m and 4m x 6m) which varied between 33-46% as compared to control.

Anjali Tiwari *et al*. (2015) carried out an experiment on effect of fertilizers on *Curcuma longa* grown under agri-silvi-horti system, and found maximum fresh weight of rhizome (235.33g) and maximum dry weight of rhizome (38.77g) were obtained in 100% NPK (120:80:80 kg /ha) + 100% FYM (20 t/ha) treatment.

Thakur *et al.* (2010) conducted an experiment with poplar based agroforestry system with intercropping of medicinal herbs for better production and diversification study. The maximum fresh leaf yield (37.87 q/ha) of medicinal plants was obtained in T1 (100kg N / ha), where in as in the 2nd plucking, yield was maximum(55.61 q/ha) in T4(4 t FYM / ha). Fresh and dry leaf yield was significantly higher in plants growing at greater distances [1-2 m (33.25 q/ha) and 2-3 m (33.84 q/ha)] than at closer distance [up to 1m (29.66 q/ha)] from the tree row.

Verma *et al*. (2010) investigated the effect of tree-crop combination and nitrogen levels on growth and herb yield of *Ocimum sanctum*. The total herbage yield showed non-significant effect on its yield due to different tree-crop combinations. The different nitrogen levels influenced the total herbage yield (above ground and below ground) significantly. The highest dose of N (120 kg/ha) gave the maximum yield (6.15 t/ha) and lowest dose (40 kg N/ha) yielded minimum (4.42 t/ha). The highest above ground (5.14 t/ha) and total herbage yield (5.56 t/ha) were achieved under Peach + Morus + Setaria + *O. sanctum.*

Thakur and Kumar (2006) studied the growth and production behaviour of medicinal herbs grown under hedge-rows of Morus. The maximum value for yield related parameters like fresh and dry weight of leaves + flowers and production efficiency were lower at the closer distance up to 60 cm as compared to 120 cm and 180 cm from the hedge-rows. Morus hedge-rows with wider plant spacing of 2.0 m and 2.5 m spacing may be adopted as suitable to cultivate medicinal herbs for diversification of farming system.

Krishnamurthy *et al.* (2006) studied on agronomic practices for growing *Centella asiatica* in high rainfall localities under open and partial shade of mango orchards and found that amongst the plant parts studied

leaves accumulated highest level of (1.091 %) of total triterpenoids content as compared to petiole (0.154 %) and root (0.251 %). *Centella asiatica* crop cultivated under shade of mango orchard produced improvement in growth and consequently yield recorded 32,538 kg/ha fresh yield for 2 years when compared to open field grown plants from six cuttings during the year. Amongst the three seasons rabi crop consistently produced higher yield in both years. Similarly higher dry yield of 5527 kg/ha/ 2year was observed under mango shade than the open field(3,281 kg/ha/2year).

Ghosh and Hore (2011) studied on economics of a coconut-based inter-cropping system as influenced by spacing and seed rhizome size of ginger and found that yield per plot of ginger was maximum with closer spacing. Maximum yield of 15.39 kg was obtained under closest spacing P1 (20 x 15 cm) but plant raised from bigger seed rhizome S2 (25-30 g) recorded the higher yield of 13.63 kg per plot as compared to 12.54 kg from small seed rhizome S1 (15-20 g).

Sharma (2015) studied Performance of *Dichrostachys nutans* and *Leucaena leucocephala* based agroforestry system in arid Rajasthan and reported that seed yield of all five intercrops recorded under agroforestry system was lower than the open field. The level of yield reduction of seasonal crops were higher under *L. leucocephala* based agroforestry. Reduction in seed yield of seasonal intercrops varied between 42.8 to 77.7 per cent. Minimum seed yield reduction was in Asaliya and maximum in Fenugreek was observed.

Thakur *et al.* (2007) studied intercropping of medicinal herbs with multipurpose tree species for improved production and higher economic benefits under upland agroforestry system in northwestern India. The greater dry yield of leaves + flower were obtained in the absence of hedgerows, which was declined in *Tagetes minuta* and *Ocimum basilicum* under different agroforestry treatments. There were no or little adverse effects on the performance and production ability of medicinal crops. The total income from agroforestry systems (Medicinal crops + Poplar) was substantially higher than monocropping of either poplar or medicinal herbs.

Vishnu solanki *et al*. (2014) conducted an experiment to find out performance of herbal medicinal crops under Sapota - Jatropha based three-tier agroforestry system. In first year sole crop of basil (T4, 29.94 kg) noted maximum fresh weight of plant per plot as compared to basil grown under sapota-jatropha (T1, 28.26 kg). Per cent reduction in fresh weight of plant per plot was recorded minimum in Basil (5.50%) followed by Mint (16%) and Kalmegh (17.70%). Significantly higher economic return were under Sapota - Jatropha as compared to sole crop, the Benefit : Cost ratio of inter crop was Basil (1:1.67) > Kalmegh (1:1.46) > Mint (1:1.40). It is recommended that herbal medicinal crops (Basil, Kalmegh and Mint) can be grown as intercrops under Sapota - Jatropha for good financial gain.

Jharna Chettri (2016) studied yield and economics of different medicinal plants influenced by forest tree species and treatment T1C1 (*Terminalia arjuna* + *Coleus aromaticus*) produced maximum yield (12409 kg/ha) with B:C ratio (3.53) followed by T2C1 (*Mitragyna parvifolia* + *Coleus aromaticus*) (3072 kg/ha) with B:C ratio (3.06). Coleus can be suitable for intercropping in old plantation with low light intensity.

Mukesh kumar *et al.* (2016) studied fresh herb weight, essential oil content and net return from *Ocimum spp*. grown under teak based silvi-medicinal system in South Gujarat. *O. gratissimum* gave higher yield above ground (6 t/ha) and total herbage yield (7.04 t/ha). The maximum essential oil recovery (0.69%) was from *O. gratissimum. O. gratissimum* produced higher fresh herb weight and essential oil, suggesting the better intercrop with teak.

Jilariya (2016) studied performance of *Aloe vera* under *Melia composita* plantation, treatment T1 (*M. Composite* + *Aloe vera* at 2m x 2m) given best performance in terms of above ground fresh biomass (86.38 t/ha), fresh mature leaf biomass (69.56 t/ha), fresh gel biomass (42.00 t/ha), fresh leaf peel biomass (27.55 t/ha), fresh mature leaf yield (1.10 kg/plant) and fresh aloin (7.58 g/plant).

Kumar and Shukla (2011) conducted an experiment to found productivity in Aonla – based hortipasture system under semi-arid condition and found associated pasture species did not show any negative impact on growth and yield of Aonla. Maximum fruit production (14.8 t/ha) was recorded with intercropping with Caribbean Stylo.

Conclusion:

Medicinal plants can be grown as an intercrop with agricultural crops and trees called as mediculture agroforestry or silvo-medicinal system. It offers a convenient way of producing many useful medi-products without displacing the traditional crops. Medicinal plants based agroforestry research in India conducted in

different parts of country with different medicinal plants like Kalmegh, Ocimum, Ginger, Tagetes, Coleus, Stevia, Aloe, Digitalis, Isabgol, Spilanthus, Centella. which cultivated with Teak, Melia, Grewia, Poplar, Morus, Jatropha, Ghamar etc. to increase productivity and good economic returns to the farmer. Fruit and medicinal trees based agroforestry with Aonla, Sapota, Ashok, Arjun. can also promoted with agricultural crops, fodder crops including medicinal herbs. The medicinal plants prioritized by NMPB for different agroclimatic zones of India need to be further integrated with mediculture agroforestry to meet out the raw material demand of herbal industry. With shrinkage of cultivable land and escalating pressure to increase agricultural production, land for the sole cultivation of medicinal plants will be a challenge which can be effectively tackled by developing integrated farming models with medicinal plants based agroforestry.

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Seminar No. 58

Speaker : **Mr. Mevada Ram. J**	Reg. No. 2030315007
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. D. Nayak**	Venue: Conference Hall
Minor Adviser: **Dr. D.P.Patel**	Date: 17/09/2016

PASTURE BASED AGROFORESTRY SYSTEMS

Grasslands, including sown pasture and rangeland are among the largest ecosystems in the world and contribute to the livelihoods of more than 800 million people. They are a source of goods and services such as food and forage, energy and wildlife habitat, and also provide carbon and water storage and the watershed protection for many major river systems. It was reported that area under pasture and fodder crops was 3.5 billion

ha (3,50,00,000 sq km) in 2000, representing 26% of the world land area and 70% of the global cultivated area. The area under permanent pastures and grasslands is about 12.4 m ha which is 3.9% of the India`s geographical area. Again, 15.6 m ha classified as wasteland, is also used for grazing. Small areas of grazing lands are found in the states of Haryana (8.9%), Punjab (5.9%) and Gujarat (4.33%), while 79.3% and 81.7% of maximum grazing lands were found in Arunachal Pradesh and Nagaland, respectively (Anon., 2002). India supports nearly 20% of the world livestock and 16.8% human population that need to be supported with only 2.3% of the world's total land area. It has been estimated that about 10 crore animals graze freely in forests, while fodder is available for only 2.8 crore animals. By 2025 the supply of green and dry fodder would be 411.3 and 488 million tons, leaving a net deficit of 65 and 25%, respectively (Anon., 2013). Development of suitable pasture based Agroforestry system would be highly welcome while addressing the presently facing problems of pasture deficit.

Brief review of research works:

1. Productive function of pasture based Agroforestry systems

Rai *et al.* (2009) studied on three multipurpose tree species (MPTs) *viz., Acacia nilotica, Dalbergia sissoo* and *Hardwickia binata* based silvipastoral system and found that pasture production (*Chrysopogon fulvus, Stylosanthes hamata, S. scabra*) maximum (6.663 t DM/ha) in control condition followed by *A. nilotica* (5.64 t DM/ha) and *H. binata* (5.739 t DM/ha) based silvipastoral systems.

Meena and Yadav (2015) revealed that *Cenchrus setigerus* gave significantly higher green (21.9 t/ha) and dry fodder yield (5.64 t/ha) than *C. ciliaris* under ber based horti-pasture system. While, application of recommended half dose of NPK @ (20+20+10) kg/ha + 5t sheep manure in grass and 250g Urea + 375g SSP + 375g MOP + 6kg sheep manure plant^{-1} gave significantly higher green (24.9 t/ha) and dry fodder yield (4.80 t/ha) as compared to sole and other treatments.

Meena *et al.* (2011) evaluated that row ratio of 2:1 in cowpea and *Cenchrus* resulted in significantly higher dry fodder yield (3.34 t/ha) followed by 1:1 row ratio under aonla based horti-pasture system. However, in case of application of N and P @ 40 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + bacterial inoculation improved in mean dry fodder yield (5.47 t/ha) as compared to other application or control treatment.

Meena (2012) observed that fresh weight of fodder yield (84,847.33 kg/ha) was maximum is lucerne fodder crop followed by berseem and Oat. Moreover, the interaction effect of tree and crop was significantly higher yield under *Mitragyna parvifolia* and lucerne crop combination which was followed by berseem under *M. parvifolia.*

Verma *et al.* (2011) studied on different tree-crop combinations and stated that *Morus alba, Setaria sphacelata and Ocimum sanctum* combination gave higher fodder yield (42.2q/ha) as compared to other combinations.

Thakur *et al.* (2015) revealed that silvi-pasture system in *Morus alba + Setaria sphacelata + Mucuna puriens* gave maximum total fodder yield in first and second year followed by *Grewia optiva + Sateria sphacelata + Mucuna pruriens.*

Ram and Kumar (2009) evaluated the buffel grass intercropped with *Stylosanthes hamata* in association with annona trees recorded significantly higher dry forage, crude protein per cent and crude protein yield when compared to *S. scabra* and also increased significantly the same with increase in P and K level from control to 40 kg P_2O_5 and 30 kg K_2O/ha which was at par with that of 60 kg P_2O_5 and 45 kg K_2O/ha.

East and Felker (1993) recorded higher crude protein content in green panic (20%), canada wildrye (20%) and virginia wildrye (21.1%) when it was grown under *Prosopis glandulosa* canopy as compared to open condition.

2. Protective function of pasture based Agroforestry systems

Mishra *et al.* (2013) observed higher organic carbon (OC), nitrogen, phosphorous and potassium in soil under the *Leucaena leucocephala + Panicum maximum* based silvipasture system as compared to without tree.

East and Felker (1993) studied on soil OC, available N and P in the various soil depths (1-15cm, 15-30cm) respectively found that under the canopy of *Prosopis glandulosa* significantly higher OC, available N and P in soil as compared to open condition.

Yadav *et al.* (2014) studied on intercropping of various grass species with *Acacia nilotica* based silvipasure system and found that significant reduction in runoff (2260 m^3/yr) and soil loss (3.1 t/ha/yr) and

increase in soil available N (12 kg/ha/yr) and P (3.5 kg/ha/yr) in *A. nilotica* + *Saccharum munja* followed by *A. nilotica* + *Vetiveria zizanioides.*

Rai *et al.* (2009) evaluated the three MPTs *viz.*, *A. nilotica, D. sissoo* and *H. binata* MPTs based silvipastoral systems and found reduction in soil pH and increased in OC, total N and available K in soil as compared to control.

3. Economic function of pasture based Agroforestry systems

Kumar and Shukla (2011) reported maximum B:C ratio (6.29) when Guinea grass + Caribbean stylo were intercropped under aonla trees followed by ratio (6.20) of aonla trees were intercropped with only Caribbean stylo.

Yadav *et al.* (2014) studied on intercropping of various grass species with *A. nilotica* and found significant increase in net returns (1,88,329 Rs/ha) and B:C ratio (2.37) as compared to sole natural grass and maximum found in *A. nilotica* + *V. zizanioides* followed by *A. nilotica* + *Eulaliopsis binata*.

Meena *et al.* (2011) observed the highest net return (30,987 Rs/ha) and B:C ratio (2.21) in row ratio 2:1 of cowpea and *Cenchrus* as compared to row ratio of 1:1 and 1:2 aonla based hortipasture system, in case of fertilizer management give highest net return (31,796 Rs/ha) and B:C ratio (1.84) found in application of N and P @ 40 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + bacterial inoculation followed by 40 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1}.

Ram and Kumar (2009) evaluated the buffel grass when intercropped with *S. hamata* under annona tree and registered highest net return and B:C ratio due to higher forage yield from this system and also maximum net return and B:C ratio obtained when applied 60 kg P_2O_5 and 45 kg K_2O/ha followed by 40 kg P_2O_5 and 30 kg K_2O/ha.

Meena and Yadav (2015) stated that Ber + *C. setigerus* gave maximum mean net return and B:C ratio than Ber + *C. ciliaris*. It was also observed that application of recommended half dose of 20+20+10kg NPK/ha + 5t sheep manure in grass and 250g Urea + 375g SSP + 375g MOP + 6kg sheep manure in $plant^{-1}$ brought maximum mean net return and B:C ratio compared to other nutrient management.

Conclusion:

Pasture based agroforestry systems is a sustainable land use system and plays a vital role for the supply of quality fodder and forage both during off season and on season to reduce the demand and supply gap. Pasture based agroforestry systems such as silvipasture, hortipasture and agrisilvipasture also helps in improving the productivity by reducing soil loss and enhance nutrient status and producing maximum economic return. So, there is need of more pasture based agroforestry systems to enhance the production of livestock and self sufficiency in fodder production.

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Seminar No. 59

Speaker : **Mr. Patel HarpalShukkarbhai**	Reg. No. 2030315008
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. M. B. Tandel**	Venue: Conference Hall
Minor Adviser: **Dr. V. M. Prajapati**	Date: 15/10/2016

VARIOUS SEED TREATMENTS USED IN FOREST TREE SPECIES

The seeds of many tree species show some degree of dormancy. It may be due to impermiability of seed coat, embryo condition or the presence of inhibitors. Seeds of some species especially those with hard seed coats, must be treated prior to sowing. The seeds treated with chemical substances, hot or cold water or abrasion to increase seed coat permeability and ensure rapid seed germination (Kalimuthu and Lakshmanan, 1995).The benefits from pre-treatment needs to be weighed against the cost and trouble of treating. The decision whether or not to pre-treat the seed will vary not only in accordance with the species but also with provenance, seed year, local nursery conditions and conditions of storage.Tree seeds which are viable but in the state of some dormancy, can be induced to germinate by various artificial treatments that break dormancyfinally resulting in early and better germination.The pre-treatment to terminate dormancy and speed up germination is thus one important type of pre-treatment.

Brief Review of Research Work:

1. Physical Treatment

Singh and Dhillon (2007) revealed that seeds when put in boiling water for 15 seconds and soaked the cooled seeds in tap water for 24 hrs enhanced germination percentage in *Acacia nilotica* (72.3%), *Prosopis cineraria* (54.0%) and *Leucaena lucocephala* (68.3%).

Khera and Saxena (2008) found that all germination parameters and root shoot ratio of *Tectona grandis* were significantly improved in cold water soaking (15days) + Humid storage (15days) whereas the growth characters and dry weight of seedlings were significantly higher when the seeds were soaked in GA_3 100 ppm for 48 hrs as compared to rest of the treatments.

Naidu and Mastan (2001) revealed that the *Pterocarpus santalinus* seeds were placed under running tap water for 6 days showed maximum germination percentage (81.0$\pm$ 2.0 %) as compared to rest of treatments.

Singh and Kumar (2014) stated that cold water soaking of seeds for 24h recorded higher germination percentage (58.67 %) and significantly higher growth in terms of vigour index (1009.3) of *Pterocarpus marsupium.*

Khantwal *et al.* (2008) found that when seeds of *Grewia disperm* and *Terminalia belirica* treated in soaking in hot water (85°C) up to 24 hrs increased germination percentage (55.10 $\pm$0.95 and 47.90 + 2.19 %, respectively).

Srinidhi *et al.* (2011) revealed that germination percentage of *Acacia holosericea* (69.33 %), *Acacia amplices* (57.33 %) and *Acacia auriculiformis* (77.00 %) enhanced by dipping of seeds in hot water for 10 min. followed by soaking for 12 hours.

An experiment was conducted on effect of pre-sowing treatments on germination of teak seeds by Saini *et al.* (1999) and found that teak seed treated with 6 min. hot water + 10 min. air cooling + 6 min. hot water + 10 min. air cooling + 6 min. hot water increased percentage of germination (60.5%) and germination value (0.75).

2.Mechanical Treatment

Chaturvedi and Das (2004) revealed that when seeds of *Acacia auriculiformis* and *Acacia nilotica* were nicked that gave highest germination percentage and germination energy but this treatment was time consuming. Moreover, the seeds of *Acacia auriculiformis* soaked in hot water at 25°C for 45minutes and in conc. H_2SO_4 for 30 minutes enhanced germination percentage (91.20 %) and germination energy (87.10 and 83.70 %, respectively). The seeds of *Acacia nilotica* when immersed in hot water for 1minute enhanced germination percentage (91.20 %) and germination energy (87.10 %).

Bahar (2012) concluded that the seeds of *Entrolobium contortisiliquum* when mechanically treated by nicking at the cotyledon endresulted higher germination percentage (93.17%) and vigour index (1024.88) with minimum germination time (8.40 days).

Dayanand and Lohidas (1988) found that the pod germination of red senders (*Pterocarpus santelinus* L.) was significantly increased by seed sowing treatment (83.5%) with (47.0 %) percentage increase over control.

3.Chemical Treatment

Bhardwaj *et al.* (2007) stated that seed pre-treated with conc. H_2SO_4 for 15 min. followed by soaking in cold water for 3 hrs. gave higher germination(55.53%), germination energy (24.40) and germination value (27.20) in *Albizzia lebbeck.*

Kalimuthu and Lakshmanan (1995) resulted highest germination percentage of *Pterocarpus santalinus* (75.8%) and *Pterocarpus marsupium* (84.5%) when seeds soaked in 40% HCL for 24 hrs.

Kumar (2002) revealed that the seeds of *Prosopis cineraria* soaked in conc. H_2SO_4 for 5minutes gave maximum germination percentage (100%). In case of *Paraserianthus falcataria* when seeds were soaked in conc. H_2SO_4 for 2 minutes gave higher germination percentage (97 %). Moreover, the seeds of *Leucaena leucocephala* and *Ceiba pentandra* when treated with boiling water for 5 minutes gave higher germination percentage with minimum days to germination.

4.Biological treatment

Omokhua *et al.* (2015) stated that termite scarification + soaking of seed for 6 hrs at 6 months of seed storage gave highest germination percentage (98.61%) in Teak (*Tectona grandis* Linn F.).

Shinde and Malshe (2015) evaluated that there was significantly early germination (15.24 days aftersowing) and the maximum germination percentage (66.11%) wererecorded in treatment of 12 hrs soaking in cattle urine+ 12 hrs keeping in cow dung slurry.

4.Hormonal treatment

Radhakrishnan and Renganayaki (2008) revealed that germination percentage (36.33 %) and vigour index (791.60) of *Simaruba glauca* were enhanced when seeds were soaked in IAA 200 ppm.

Ghyare (2005) evaluated that when seeds of *Albizzia lebbek, Bombax ceiba, Cassia siamea, Prosopis juliflora* and *Tamarindus indica* were treated with GA_3 @ 400 ppm gave cent percent germination percentage.

Masilamani and Dharmalingam (2002) resulted higher germination percentage (43 %) and vigour index (523) of*Grevillea robusta* when seeds treated with GA_3 @ 250 ppm.

Sudhakara and Veenadevi (2013) concluded that treatment of GA_3 @ 300 ppm overnight soaking increased cumulative germination percentage (66.50 %), mean daily germination (0.83), peak value of germination (1.07) and germination value (0.91) of *Vitex altissima.*

Conclusion:

The various physical treatments of soaking seeds in boiling water, hot water, tap water, cold water, alternate soaking and drying; mechanical treatments by nicked and seeds extracted from pod; chemical treatment by dipping of seeds in conc. H_2SO_4 and HCL; biological treatment by termite scarification and soaking of seeds in cattle urine & cow dung slurry and hormonal treatment of IAA & GA_3enhanced germination percentage and vigour index of seeds of various tree species.

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Seminar No. 60

Speaker : **Mr. Patel Hirajkumar Bhartabhai**	Reg. No. 2030315009
Degree : M.Sc. Forestry (Forest Biotechnology)	Course No: FOR-591
Major Adviser: **Dr. S. K. Jha**	Venue: Conference Hall
Minor Adviser: **Dr. M. S. Sankanur**	Date: 15/10/2016

STATUS OF MOLECULAR VARIABILITY STUDIES OF MANGROVES IN INDIA

Mangroves are associated with estuarine and coastline ecosystems. They are quite diverse in ecological structure and dynamics. The plant species that form a part of this ecosystem are constantly under environmental stress due to high saline conditions and extreme temperatures and have adapted themselves to these frequent and fluctuating changes. Spatial patterns in genetically adaptive traits indicate that some populations survive more successfully under changing environment conditions (Dodd and Rafii, 2002). Assessment of the genetic differences between populations of the same species and with different species gives a measure of the extent to which such populations are generally isolate or differ from each other, while genetic comparison of different species shows information about the extent of divergence and potentially. Molecular markers have been used to quantify accurately the extent of genetic diversity within and between populations (Chalmers *et al.* 1994). Molecular markers are widely used to quantify genetic diversity within and between populations since they are not prone to environmental influences and portray true genetic relationships between plant groups (Arif *et al.* 2010; Oliveira *et al.* 2010). Information on current status of use of markers in variability study of manrove is required for further conservation, planning and management.

Brief Review of Research Work:

Das et al. (2011) studied on genetic variability among male populations of Excoecaria agallocha.They used eleven RAPD primer and five ISSR primer. Dendrogram clustered the population into two major clades, the first cluster included Gopalpur and Chilka whereas second included Chandipur, Paradeep and Bhitarkanika populations. PCA confirmed the UPGMA clustering pattern.

Pawar et al. (2013) analysed genetic diversity among three species Xylocarpus granatum, X. moluccensis and X. Mekongensis by RAPD marker. They used 25 RAPD 10-Mers primer and found total 283 number of loci with an average of 11.32 loci per primer. Dendrogram and pair wise polymorphism comparison between species showed higher similarity between X. mekongensis and X. moluccensis, whereas X. granatum and X. mekongensis showed lower similarity.

Das and Jena. (2008) studied on the inter population genetic variability among eight populations in tree mangrove Xylocarpus grantum using 10 RAPD primers. Total 444 amplicons generated by these primers. Number of polymorphic band was highest in Pop-III, however maximum number of unique band identified in Pop-VI. Two major clusters were generated by Jaccards similarity index values. First cluster included only one population (Pop-VI). Remaining all the population formed a large clusted. However second cluster was further subdivided in to three sub-clusters.

Lakshmi et al. (1996) analysed intraspecific genetic variability in the mangrove species Acanthus ilicifolius. Random amplified polymorphic DNAs (RAPDs) and restriction fragment length polymorphisms (RFLPs) were used to elucidate the intra and inter population variability. A low level of polymorphism was detected at the intra-population level through both RAPD (3.8-7.3%) and RFLP (3.2-9.1%) analyses.Dendrogram constructed for two eastern coast population and three western coast population revealed that there was distinct differentiation between them.

Sarkar *et al.* (2012) studied the genetic variation of *Xylocarpus mekongnensis, Xylocarpus grantum* and *Heritiera fomes.* They found that intra specific polymorphism was highest (80%) in *Xylocarpus grantum* and lowest in *Xylocarpus mekongnensis* (60%) while *Heritira fomes* showed moderate (71.42%) level of polymorphism.

Das *et al.* (2015) investigated on phylogenetic relationships among the mangrove species of Acanthaceae found in Indian Sundarban by RAPD analysis. Oligo-8 showed maximum polymorphism (100%). However, highest number of polymorphic loci was generated by Oligo-09. The dendrogram reveals that the five species under study exhibits an overall similarity of 60.7%. *Avicennia alba* and *A. officinalis* (cluster C1) have very close relationship between them and share a common node in the dendrogram at a 73.3% level of similarity. *Avicennia marina* and *Acanthus ilicifolius* (cluster C2) also have close relationship between them as evident by a common node in the dendrogram at 71.8% level of similarity. *Acanthus volubilis* showed 68.1% similarity with cluster C1 and 60.7% similarity with cluster C2.

Das *et.al* (2014) studied the phylogenetic relationships among three species of the mangrove genus Avicennia of Sundarban, by RAPD analysis. They used ten primers amplified a total number of 221 bands under 100 loci across three genotypes with an average of 10 loci/primer, the total 100 loci scored from that 50 were polymorphic. Thus the average percentage of polymorphism was 50%. Different primers yielded a total of 7 unique bands for *Avicennia alba*, 14 For *A. Marina* and 8 for *A. officinalis* was found. The dendrogram reveals that *A. alba* and *A. officinalis* have closer relationship between them and share a common node in the dendrogram at a 73.3% level of similarity.

Jena *et al.* (2006) investigated inter-population variation by RAPD markers in *Suaeda nudiflora* (Willd.) mangrove species in India. They used ten RAPD primer. They found total amplified bands was 132 with an average of 3.64 bands per population per primer. The dendogram based on the RAPD analysis showed that Pop-III and Pop-V showed a closer affinity with 64% of similarity while the Pop-IV showed a very less close similarity with Pop-III (53%) and Pop-V (61%) and The highest value of mean similarity coefficient 0.57 was found in Pop-II, followed by Pop-III (0.56). The lowest value of mean similarity coefficient was recorded for the genotype collected from Pop-IV.

Conclusion:

Molecular marker has immense potential in deciphering diversity in mangrove. So far, only a few markers eg. RAPD, ISSR and RFLP has been successfully utilized to know inter and intra-species variation in some mangroves of India. Though the study shows large amount of variability existing at inter and intra population level, in all the study population size found to be less. Use of advance generation markers with large population coverage is still lacking which can give us more information about mangrove diversity for conservation and management of unique ecosystem.

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Seminar No. 61

Speaker : **Mr. Patel Minalben Hemanshubhai**	Reg. No. 2030315010
Degree : M.Sc. Forestry (Medicinal & Aromatic Plants)	Course No: FOR-591
Major Adviser: **Dr. B. S. Desai**	Venue: Conference Hall
Minor Adviser: **Dr. S. K. Jha**	Date: 15/10/2016

PLANTS AS A SOURCES OF ANTIOXIDANTS AND NUTRACEUTICALS

Antioxidant is a molecule capable of slowing or preventing the oxidation of other molecules. Oxidation is a chemical reaction that transfers electron from a substance to an oxidizing agent. Oxidation reactions can produce free radicals, which start chain reactions that damage cells. Oxidative stress can be caused by environmental factors, disease, infection, inflammation, aging (ROS production).ROS or Reactive oxygen species include free radicals and other oxygenated molecules resulting from these factors. Antioxidant constituents of the plant material act as radical scavengers, and helps in converting the radicals to less reactive species. A variety of free radical scavenging antioxidants is found in dietary sources like fruits, vegetables and tea, etc. This review presents some information about the antioxidants/antiradicals and their role in our body and also their presence in spices and herbs. Flavanoids and other poly phenols, Vit. C & E and carotenoids are the most common dietary antioxidants. Many herbs and botanicals also conation a high antioxidant. (Gupta and Sharma, 2006). The term nutraceutical was coined from nutrition and pharmaceutical *in 1989 by Stephen Defelice. MD, founder and chairman of the Foundation for Innovation in Medicine (FIM), (New York, US). According to him "a nutraceutical is any substance that is a food or a part of food and provides medical or health benefits, including the prevention and treatment of disease".* The definition of nutraceuticals has been expanded to include vitamins, minerals, herbs and other botanicals, amino acids, and dietary substance for human use as a supplement diet. Hippocrates highlighted around 2000 years ago "Let food be your medicine and medicine be your food". In a nutshell, Nutraceuticals are foods or food ingredients that provide medical or health benefits. This emerging class of products blurs the line between food and drugs. They do not easily fall into the legal categories of food or drug and often inhabit a grey area between the two.(Pandey *et al.*2010). Indian nutraceuticals market was valued at US $ 1480 million in 2011and is expected to be roughly US $ 2731 million by 2016. The Indian nutraceutical market is estimated to grow to US $ 2731 million in 2016 at a CAGR of 13% functional foods will be quickest growing category till 2015 followed by dietary supplement. (Mitra and Das, 2015)

Brief review of research work:

Vaidya and Devasagayam (2007) stated that Indian medicinal plants provide a rich source of antioxidants and there were over 40 Indian medicinal plants showed antioxidant abilities at various levels of protection.

Shukla *et al.*(2015) described biological activities of lichen genus *Usnea* like anti-tumor, anti-microbial and also have a antioxidant potential.

Naguib (2000) investigated radical scavenging activities of α-Tocopherol and Astaxanthin from *Haematococcus pluvialis* by Oxygen radical absorption capacity method and get the maximum in 220 concentration (1.37) and in Astaxanthin 145 concentration (1.24).

Shrivastava *et al*. (2014) observed antioxidant activity of *Adiantum* and *Pteris* ferns through DPPH and observed maximum scavenging activity (%) in both plant leaf (0.98, 0.97) and stem (0.99, 0.94) parts, respectively in 1 µg/ml concentration.

Kalvina L. (2015) screened different species of bryophyte extraction through optimal extraction method with solvent 60% ethanol. In that the *Polytrichum splendens* gives the maximum total phenol content (800.7 GE 100 g^{-1}) and *Hylocomnium splendens* gives the maximum radical scavenging activity (59.3 GE 100 g^{-1}).

Nahak and Sahu (2011) revealed that the ethanol fraction of *Piper cubeba* exhibited the highest radical scavenging activity (77.61±0.02) followed by its methanolic extract (69.84±0). In comparison to *Piper cubeba* and *Piper nigrum* extract showed less scavenging activity. The *Piper nigrum* extract obtained from ethanol showed highest scavenging activity (74.61±0.02) followed by its methanolic extract (63.84±0.05).

Patel *et al.* (2010) stated that total phenol content in the tissues was varied from 47.28 to 4.88 mg/g in screened of five plant. The amounts of phenols were higher in the stem tissues when compared to leaf tissues of all the plants studied. Maximum amount of phenols were found in the *Gmelina* (47.28 mg/gm Dr.wt.) plant followed by *Kigelia, Hibiscus, Calatropis* and *Parthenium*. Major amount of phenols were determined in *Gmelina* leaf followed by *Kigelia* stem and *Hibiscus* stem. The flavanoid content varied from 1.27 mg/g to 82.11 mg/g. High amount of flavonoid content was observed in the leaf tissues when compared to that of the stem tissues. High amount of flavonoid content was observed in the *Hibiscus* (82.11 mg/g Dr.wt.) followed by *Gmelina, Parthenium, Calotropis* and *Kigelia*.

Veeru *et al.* (2009)) revealed that the free radical scavenging action of methanol extracts of plant were in the order as *Desmodium gangeticum* (0.19 mg/l) > *Amaranthus caudatus* > *Solanum nigrum* > *Piper longum* > *Eclipta alba* > *Ocimum sanctum* (0.05 mg/l). The extracts, which showed the strongest DPPH radical scavenging activity, were *D. gangeticum* and *A. caudatus* while the others showed moderate antioxidant properties.

Balakrishnan *et al.* (2011) screened 13 medicinal plants in aqueous system and found that *Hyptis suaveolens* leaf (98.06%) showed the strong inhibition of DPPH radical followed by the leaf extract of *Alpinia calcarata* (97.4%) inhibition. Aqueous extract of *Ocimum basillicum* leaf (95.08 %) and aqueous extract of *Passiflora edulis* fruit (95.68%) possessed almost the similar percentage inhibition of DPPH radical. In case the ethanolic solvent system, *Ocimum basillicum* leaf ranked first with the percentage inhibition of DPPH radical (96.18%) which was followed by *Alpinia calcarata* leaf with the percentage inhibition of 94.63 %.

Panmei and Soram (2014) investigated methanolic extracts of two plants and observed that DPPH radical scavengers were most effective and showed percent inhibition of DPPH activity- *Syzygium cumini* (88.9%) and *Oroxylum indicum* (84.4%). The extract of seed of *Meyna spinosa* (30%) showed somewhat moderate radical scavenging activity, whereas the extract of the fruit *Lagenaria siceraria* (17%) contained remarkable lower amount of radical scavenging compound.

Schmidt and Pokony (2005) studied on oilseed cakes and found that extracted meals contained nonpolar antioxidants, antioxidants of medium or high polarity, mainly phenolic acids, their esters, flavonoids and their glycosides, or lignan derivatives. They possessed moderate antioxidant activities; nevertheless, they could be applied with success in special foods.

Patil & Dhale (2013) investigated the spices have an antioxidants. Which are Carnosol, Carnosoic acid and Rosmanol etc. from the spices like Rosemary, Sage, Turmeric etc.

Srinivashan and Durairaj (2014) observed that the *Morinda citrifolia* Fruit contained an enzymatic and non-enzymatic antioxidants which are Superoxide dismutase, Catalase, Peroxidase, Glutathione reductase, Glutathione transferase, Ascorbic acid, α-tocopherol , Carotenoids (vit A, Flavonoids, Phenols , Tannins , Carbohydrates).

Dimitrios (2006) investigated herbal tea with water extracts methods for phenolic antioxidants and compared to the total antioxidant capacity of tea infusions. Most of the traditional herb extracts were prepared from parts of the *Lamiaceae* family plants.

Pushpangadan *et al.* (2010) stated that the ancient medical masters had developed certain dietary and therapeutic measures to arrest/delay ageing and rejuvenating and other elements of whole functional dynamics of the body system.

Gupta *et al.* (2010) studied the various categories of dietary supplements in which ketogenic diet was used to comprise of foods with high fat and low protein and carbohydrate content and reported to improve seizure control. Others were minimally refined grains like cereals fortified with calcium which may reduced the incidence of diabetes. Phytoestrogens found in soya flour and linseeds have been documented estrogens to increase the levels when hormonal levels were low. They were also found effective against breast cancer. They also suggested various nutraceuticals used to combat major disease were cardiovascular, cancer, obesity Alzheimer's disease, Parkinson's disease etc.

Pandey *et al.* (2011) prepared a list of some common chemical compounds isolated from plants used as Nutraceuticals with its properties and used in Cancer, Ophthalmic disease, Age-Related Macular Degeneration (AMD) etc.

Alissa and Ferns (2012) stated that various nutraceutical that was present in nuts (Tocopherols, omega-3 fatty, acids), legume (fiber and poly phenols), Fruits & vegetables etc. can be used for lowering blood cholesterol. They also found that ppotential nutraceutical *viz.*, Lycopene from Tamato, Carotenoids from green leafy vegetables and fruits, Vitamin C from Citrus and other vegetables etc act as an antioxidant.

Conclusion:

Climate change and changing lifestyle has exposed human race to many diseases. Though our immune system tries to protect us from various ailments but sometimes it is not sufficient. Higher price of commercial drug to cope up with these disease are sometime not affordable by poor peoples. Supplementary diet containing essential nutrient, antioxidants and phyto-chemicals are now a day proved very useful to treat fatal diseases including cancer, Alzheimer and Parkinson's diseases. It's time to adopt ancient wisdom including Indian Ayurveda and greek philosophers under the light of current scientific discoveries in nutraceuticals who directs us "Let food be your medicine and medicine be your food". The present seminar has thus focussed on various sources of plant groups exhibiting antioxidant properties and has also thrown light into different forms of Nuetraceuticals available from vast plethora of plants. Molecules like Resveratrol, Lycopene, Carotene, Catechins, Phenols and their derivatives play very crucial role in combating free radicals which are now clinically proven to cause various chronic diseases in human beings.

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Seminar No. 62

Speaker : **Mr. Sohagiya Nileshkumar Jaysukhbhai**	Reg. No. 2030315011
Degree : M.Sc. Forestry (Wood Science & Technology)	Course No: FOR-591
Major Adviser: **Dr. S.K. Sinha**	Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 15/10/2016

RADIAL VARIATION OF ANATOMICAL PROPERTIES IN DIFFERENT HARDWOODS

The trend of variation in wood from pith to periphery is known as radial variation. Most trees have a pattern in wood qualities from the centre of the tree outward, from the base to the top of the tree, within an annual ring, and sometimes even on different sides of the tree in relation to the sun and temperature (Zobel and van Buijtenen, 1989). The variability in anatomical characteristics has profound influence on properties of wood It includes the variation of various parameters like fibre parameters (fibre length, fibre width, fibre lumen width, fibre wall thickness), vessel parameters (vessel diameter, vessel frequency, vessel length), and tissue proportions (fibre percentage, vessel percentage, ray percentage, axial parenchyma percentage).The general pattern of

variation in wood element dimensions is found not only within a species but also observed within a tree (Zobel, 1965). Study of radial variation of wood anatomical properties is essential to determine the uniformity of wood and also to predict the effect of age on wood quality. The greater the uniformity of wood, the greater will be the efficiency of producing a specific product with much improved quality of the final product.

Brief review of research work:

Saravanan *et al.* (2013) studied the radial variations of anatomical parameters at five different ages in *Melia dubia* from Tamil Nadu. They reported the mean values of vessel length (258.89, 269.39, 300.17µm), vessel diameter (203.04, 231.86, 258.27µm), ray height (359.47, 382.50µm), ray width (71.47, 85.36, 97.36 µm), fiber length (824.47, 924.27, 962.06µm), fiber diameter (24.18, 25.61, 27.71µm), double wall thickness (5.97, 6.49, 7.07µm) and lumen diameter (12.25, 12.63, 13.57µm) at pith, middle and periphery of one to five years old *M. dubia* wood respectively. All parameters increased significantly from pith to periphery except lumen diameter at five different ages.

Chowdhury *et al.* (2012) studied on the radial variation of anatomical properties in 10 years old *Casuarina equisetifolia* grown in Bangladesh. They revealed that the average vessel diameter increased gradually between sample points 2.5 cm and 7.5 cm from the pith. Vessel frequency decreased between sample points 2.5 cm and 5 cm from the pith and then stabilised. Average fibre diameter decreased gradually from pith to bark, while fibre wall thickness displayed a reverse trend. The proportion of vessels decreased slightly between the 2.5 and 5 cm sample points and then increased again towards the bark. Fibre and cell wall proportions increased from the pith to bark. The proportion of rays was nearly constant along the radius, while the proportion of axial parenchyma decreased somewhat toward the bark.

Anoop *et al.* (2014) carried out an experiment on radial variation of anatomical properties in 1.11 to 1.56m girth class of *Swietenia macrophylla* from Kerala and they found that vessel area and diameter varied significantly along the radial directions from pith to periphery and increased from inner to outer tissue. The dimensions of ray elements like ray height and width increased from pith whereas, ray frequency declined from pith to periphery. Among the fibre dimensions, the length and wall thickness varied significantly due to position. The percentage contribution of vessel, ray, fibre and parenchyma didn't show significant variation along the radial directions.

Lima *et al.* (2015) worked on experiment of average of anatomical features in the three different diameter classes: large (33cm), medium (26.5cm) and small (22.4cm) in 24 years old *Liquidambar styraciflua* planted in Sao Paulo State, Brazil. They observed that the radial variation showed an increase in vessel length, vessel diameter, fibre length, fibre diameter, fibre wall thickness, and decrease in fibre lumen diameter, vessel and ray frequencies from pith to bark.

Pande *et al.* (2010) observed pith to periphery variations in wood element's dimensions in micro and macro propagated 6 years old L34, G3 and S7C15 clones of *Populus deltoids*. They concluded that, in macro propagated plantations of clone L34 fiber diameter, fibre wall thickness and vessel diameter increased towards the bark whereas, fibre and length decreased in macro-propagation and it is increased in micro-propagation of the same clone towards the bark. In macro propagated G3 clone fibre length, vessel length and vessel diameter increased towards periphery, while in micro propagation fiber diameter and vessel length showed a decreasing pattern. In micro and macro propagated S7C17 clones fibre length and diameter increased outward from the pith, while in micro propagation of same clone vessel diameter decreased and fibre wall thickness remained more or less constant towards the bark.

Chowdhury *et al.* (2013) conducted experiment on variation of wood anatomical properties in 11 years old trees of *Acacia auriculiformis* in relation to radial distance (20, 40, 60, 80 and 100%) from pith. They reported that vessel diameter increased gradually up to about 40-45% distance from pith and then levelled-off to bark. Fibre diameter gradually decreased towards bark, whereas fibre wall thickness showed a reverse pattern. In contrast to fibre proportion, vessel and ray proportions gradually increased from pith to bark.

Anoop *et al.* (2016) studied the anatomical properties of 88 years old *Pericopsis mooniana* along the radial direction. They found that mean value of ray width (22.3, 29.1, 34.9µm), ray per cent (18.11, 26.47, 32.56µm), fibre length (1327.3, 1222.9, 1170.1µm) and fibre per cent (34.52, 26.53, 21.52) at pith, middle and periphery respectively.

Mohammed and Nasroun (2012) investigated the radial variation of fiber length *Ailanthus excelsa* and they revealed that the average fiber length for different zones decreased from zone 4 to zone 2 and then increased at zone 1. The highest value was 1.34 for zone one while the lowest value was for zone two (1.22mm).

Longui *et al.* (2014), in their studies of wood feature variations of *anadenanthera colubrina* from pith to bark, they found that vessel length, vessel diameter, fiber length, and fiber wall thickness were minimum at pith, it was respectively 486, 92, 663 and 3.6 μm. While maximum at periphery those values were 545, 150, 1054 and 4.4 μm.

Bhatt *et al.* (1989) studied fibre length variation in the main stem of different eleven tropical hardwoods from the pith to periphery and they reported that fibre length initially increased from pith outwards to reach a maximum value and then decreased towards the bark. Fibre length declined near the bark was such that fibre length values were almost similar near the pith and bark.

Honjo *at el.* (2005) investigated the radial variation of wood fiber length (WFL) and vessel element length (VEL) in young and old trees of *Acacia mangium* and they found that *WFL* of all the trees was shortest near the pith, and gradually increased from the pith towards the bark, irrespective of tree dominance. The range of the shortest *WFL* in the vicinity of the pith was 0.4 to 0.6 mm, and there were no clear differences in the radial variation of these trees. However, the variance in *WFL* between trees increased with increasing distance to the pith, in the outer portion of the stem.

Ishiguri *et al.* (2009) studied radial variation of anatomical characteristics in 13 years old *Paraserianthes falcataria* planted in Indonesia and concluded that fiber diameter was almost constant (15 to 20 μm) from pith to bark; fiber wall thickness showed an almost constant value up to 10 cm from the pith and then increased toward the bark; The vessel percentage and axial parenchyma percentage showed an almost constant value up to 10 cm from the pith and then increased toward the bark; the wood fiber percentage decreased from 10 cm to the bark; no consistent radial pattern was found in the ray parenchyma percentage, cell wall percent showed low values near the pith and high values near the bark.

Kiaei and Bakhshi (2014) worked on the radial variations of wood different properties in 25 years old *Diospyros* lotus and they reported that fiber length, fiber diameter and cell wall thickness, along radial direction increased from pith to bark.

Adamopoulos *et al.* (2011) experimented the radial variation of fiber length in 35 to 37 years old Black locust (*Robinia pseudoacacia L.*) and 25 to 27 year old Chestnut (*Castanea sativa Mill*.) and revealed that in both species the fiber length increased rapidly up to 10 years, after that it became slightly constant.

Sharma *et al.* (2014) studied radial variation in wood properties from pith to bark in 16 years old *Terminalia myriocarpa* and revealed that rapid increase in fibre length up to 40 mm distance from pith and afterwards it increased gradually. Fibre length ranged from 736.68 μm to 1300.03 μm. While vessel length showed gradual increase from pith to bark and range of vessel length from pith to bark varied between 341-431 μm.

Veenin *et al.* (2005) did research on radial variations of anatomical characteristics in 5 years old *Eucalyptus camaldulensis* clones and reported that vessel diameter of clone 2, clone 3 and clone 5 strongly increased in the first 3 to 4 cm from the pith, and in the seedling strongly increased in the first 5 cm from the pith and then slightly increased with little fluctuation to the bark, For clones 1 and 4, the tangential vessel diameters slightly increased with a little fluctuation or were nearly consistent from pith to bark. Vessel area is consistent from pith to bark. Mean fiber diameter is largest in clone 3, while the seedling differed from the clones as the fiber diameter gradually decreased from pith to bark. Fiber length of the 5 clones steadily increased from the pith outward with very little fluctuation, while the seedling showed a rapid increase in the first 5 cm from the pith and beyond this area it showed a slight increase with fluctuation to the bark.

Conclusion:

In most of the hardwoods, the anatomical properties like dimension of fibre, ray, vessel and their proportion increased up to certain distance from pith or in the middle of the tree and decreased or stabilized towards the bark except fibre lumen diameter, vessel frequency, ray frequency and fibre proportion. Knowledge of radial variation of anatomical properties of wood is essential to characterize the basic density, juvenility and maturity of wood in particular tree species. These characteristics are important to determine the uniformity of wood to make the specific end products of improved quality.

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Seminar No. 63

Speaker : **Mr. Sumit Mohanty**	Reg. No. 2030315014
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. N.S. Thakur**	Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 26/11/2016

POTENTIAL OF AROMATIC PLANT BASED AGROFORESTRY SYSTEM IN INDIA

Aromatic plants possess odorous volatile substances which occur as essential oil, gum exudates and oleoresin in one or more parts, namely, root, wood, bark, stem, foliage, flower and fruit. They are used in cosmetic, soap, pharmaceutical, perfumery, confectionery industries as well as in ice-creams, aerated waters disinfectants, tobacco, agarbatti, *etc*. and in agriculture as antifeedants, repellents, botanical insecticides, natural herbicides. The estimate of world production of essential oils varies from 40,000 to 60,000 tonnes per annum and at raw material level a business of around $10 billion annually. Unscientific extraction of these natural healers has rendered many of these plants on the verge of extinction. Therefore, to conserve them in wild *vis a vis* cater the requirement of industry, there is need of commercial cultivation. Many medicinal and

aromatic plants (MAPs) are naturally growing under forest cover and are shade tolerant. Such valuable plants provide the cue to cultivate them under such land use system having the conditions similar to their natural habitat. Hence, agroforestry appears to be the ideal land use for commercial cultivation of aromatic plants. Such silvi-medicinal practices provide openings to diversify agriculture as well as cater the needs of MAPs based industries. Shift from collection to cultivation of medicinal plants would also ensure purity, authenticity and sustainable supply of raw materials to various end users such as pharmaceutical industries.

Brief Review of Research Work

1.Growth performance of aromatic crops under Agroforestry systems

Yadava *et al*. (2009) reported that number of tiller/plant, plant height, herbage yield and oil yield of lemongrass (*Cymbopogon flexousus)* grown under poplar (*Populus deltoides*) were maximum at 40 X 40 cm spacing with $N_{200}P_{40}K_{40}$.

Pujar *et al.* (2007) cultivated aromatic plants *viz.*, coleus (*Coleus forskohli*), citronella (*Cymbopogon wintereanus*), lemongrass (*Cymbopogon flexuosus*), palmarosa (*Cymbopogon martinii*) and patchouli (*Pogostemon patchouli*) as intercrop under teak and observed reduction of growth in all the crop, except coleus indicating Coleus is compatible combination under teak.

Singh *et al.* (1989) reported that performance of two aromatic grasses *viz., C. flexousus* and *C. martinii*, in terms of herbage and oil yield, was better under *Eucalyptus hybrid* as compared to *Populus deltoides*.

Kumar *et al.* (2016) grew three *Ocimum* spp. namely *O. tenuiflorum*, *O. gratissimum* and *O. basilicum* under teak and compared with sole crop. Result showed that maximum total herbage yield and essential oil recovery obtained in sole crop. Among intercrops, *O. gratissimum* gave higher total herbage yield (7.04 t/ha) and oil yield (46.57 kg/ ha) than others.

Nath *et al*. (2015) reported reduced yield of MAPs *viz.*, Pipali (*Piper longum*) and Vedailota (*Paederia foetida)*, Citronella (*Cymbopogon winterianus*) and Patchouli (*Pogostemon cablin*) grown under coconut garden compared to respective sole crop yields. The reduction in yield was less in patchouli (5.2%), followed by Vedailota (7.0%), Pipali (9.0%) and Citronella (16.8%).

Thakur and Dutt (2007) observed higher reduction in herbage yield of *Ocimum santum* under poplar with varying spacing as compared to sole crop. There was no adverse effect on herb yield between 1-2 m distance from tree row, specially (8 x 3m and 6 x 4m); whereas it was reduced at closer poplar spacing (5 x 5 m and 4 x 4m), which varied between 33-46 per cent as compared to control. Herbage yield with and without poplar was greater during second year than first year.

Suvera *et al.* (2015) carried out an investigation on four species of *Ocimum* intercropped under Karanja (*Pongamia pinnata*) based silvi-medicinal systems and sole cropping system. Out of four *Ocimum* spp., maximum total herbage yield (12.05 t/ha) and oil yield (61.32 kg/ha) were obtained from *O. tenuiflorum*. Significantly higher total herbage and oil yield of *Ocimum* spp. was recorded under silvi-medicinal systems compared to sole cropping.

Raj *et al.* (2010) studied impact of fertilizer and spacing on *C. flexousus* intercropped under poplar and reported maximum herbage yield of 48.6t/h and 52.3 t/ha with fertilizer dose ($N_{150}P_{60}K_{60}$ Kg/ha) at spacing of 30 X 45 cm for both shade (poplar) and open condition, respectively.

Sehgal (2011) investigated effect of *Leucaena* hedge-rows and organic manures on *O. basilicum*. Economic herb yield was higher at wider spacing within the hedge-rows, where enriched manures had been applied to the alley crop. Economic yield was minimum in control during both the experimental years.

Solanki *et al*. (2014) studied the performance of MAPs under Sapota+Jatropha based agroforestry system and observed higher fresh weight of basil in sole crop as compared to that grown under agroforestry system. Per cent reduction in fresh weight of plant was recorded minimum in basil (5.50%), followed by mint (16%) and kalmegh (17.70%).

Singh *et al*. (1990) intercropped six species of aromatic under newly planted poplar and reported that herbage and oil yields of *Mentha* spp. were not affected in the first year, however, reduced by 10-26 per cent and 8-24 per cent, respectively over the next 2 years due to shading effect. However, in *Cymbopogon* spp., very small reduction was observed in herbage and oil yields over the 3 years (1.3-2.4 % and 0.5-4.5%, respectively). Thus, *Cymbopogon* spp. appeared to be more suitable companion crop for poplar than *Mentha* spp.

Kumar and Naugraiya (2013) reported reduction of dry matter and oil production of *C. flexousus* under *Dalbergia sissoo* based agroforestry system over sole cropping during two cropping year.

Verma *et al.* (2010) studied effect of tree crop combinations (Peach+Morus/Grewia+Seteria+*O. Santum*) and nitrogen levels on herbage yield of *O. sanctum* and stated that the negative effects of tree species can be minimized, if proper spatial arrangements are adopted. The different N level influenced the total herbage yield significantly. Nitrogen @ 120kg/ha gave maximum yield (6.15 t/ha) and highest total herbage yield (5.56 t/ha) under Peach+Morus+Seteria+*O. santum.*

Nagarajaiah *et al.* (2012) intercropped coleus (*Coleus forskohli*), citronella (*C. wintereanus*), lemongrass (*C. flexuosus*), palmarosa (*C. martiniii*) and patchouli (*Pogostemon patchouli*) with teak and found marginal reduction in herbage yield of all the aromatic crops, except coleus.

Chand *et al.* (1998) estimated biomass and essential oil yield of lemon scented gum (*Eucalyptus citriodora*) and lemongrass (*C. flexuosus*) in agroforestry system. Biomass and essential oil yield of *E. citriodora* does not affects the intercropping of one or two row(s) of lemon grass; whereas biomass (72.30t/ha) and essential oil yield (216.91 l/ha) were significantly higher under *E. citriodora* planted in 2 rows than one row.

Thakur and Kumar (2006) studied growth and production behavior of *O. sanctum* under hedge row of Subabul (*Leuceana leucocephala*). The maximum value for yield related parameters like fresh (81.98 q/ha) and dry weight (26.24 q/ha) of leaves +flower and production efficiency (132.5 kg/ha/day) were recorded in the absence of hedge row (Control), whereas the yield was lower at closer distance up to 60 cm as compared to distance of 120 and 180 cm from the hedge row. The study suggested that wider spacing (2.0 m and 2.5 m) of *Leuceana* hedge row may be adopted with minimal negative effect of herbage yield of *O. sanctum.*

Mohsin and Singh (2003) reported that the primary productivity of Nilgiri (*Eucalyptus hybrid*) was highest in stand intercropped with *Mentha arvensis* and lowest with *Cymbopogon winteranus* at all age of the stand, which suggests that *M. arvensis* be the best companion crop for *E. hybrid.*

Economics

Mohandas (2011) evaluated the aromatic plants *viz., Alpinina galangal*, *O. sanctum*, *C. flexuosus* and *P. patchouli,* as intercrop under coconut garden for economic feasibility and it is reported that, among all the crops, *A. galangal* gave highest net return (Rs 89,898) with benefit-cost ratio (B:C) of 1.32.

Kumar *et al.* (2016) cultivated three *Ocimum* spp. namely, *O. tenuiflorum, O. gratissimum* and *O. basilicum* under teak and sole crop. Among three *Ocimum* spp., highest net return of Rs.103327ha^{-1} and B:C ratio of 2.56 from essential oil were accrued from *O. basilicum* grown as sole crop.

Solanki *et al*. (2014) obtained significantly higher economic return (B:C ratio of 1:1.67) from Sapota+Jatropha-basil based agroforestry system as compared to sole basil.

Nath *et al*. (2015) reported that among Coconut+Pipali (*Piper longum*)/Vedailota (*Paederia foetida)*/ Citronella (*C. winterianus*)/ Patchouli (*P. cablin*) systems, Coconut+patchouli provided the highest net income (Rs. 1.78 lakh ha^{-1}) and B:C ratio (3.26), followed by Pipali (Rs. 1.13 lakh ha^{-1} and 2.62), Citronella (Rs. 1.07 lakh ha^{-1} and 2.40) and Vedailota (Rs.1.00 lakh ha^{-1} and 2.36).

Conclusion:

Aromatic plants like Lemongrass, Palmarosa, Citronella, Pachouli, Coleus, Galangal, Ocimum and Mints studied or practised in different part of country experienced either enhanced or reduced herbage and/or oil yield under teak, poplar, subabul, Karanj, coconut and/or Nilgiri. Some of the studies suggest that reduction in yield of intercrops under Agroforestry system may be minimized if proper tree crop combinations with better spatial arrangements are adopted. Economics shows that some of the crops grown under Agroforestry system resulted in higher returns and more B: C ratio indicating potentiality of aromatic crops grown under AF system. Therefore, intercropping of aromatic plants under timber/fruit/fodder tree species could be remunerative and may lead to judicious utilization of inter-space in the AF system. Thus, aromatic plant based agroforestry systems holds good potential even though reduction in yield in some extent it may occur.

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Seminar No. 64

Speaker : **Mr. H. T. Hegde**	Reg. No. 1030314002
Degree : Ph.D Forestry (Forest Genetic Resources)	Course No: FOR-691
Major Adviser: **Dr. R.P. Gunaga**	Venue: Conference Hall
Minor Adviser: **Dr. S.K. Jha**	Date: 26/11/2016

STRATEGIES FOR CONSERVATION OF FOREST GENETIC RESOURCES IN INDIA

Forests are the world's most important and valuable renewable natural resources and also repositories of terrestrial biological diversity. Since forests are long-living, out-breeding is generally more heterogeneous and found in variable environments and hence, they have developed complex mechanisms to maintain high intraspecific diversity (Majeed *et al.,* 2011). It is well recognized that genetic variation is essential for species to evolve and adapt to changing environmental conditions. Forest genetic resources (FGR) are the heritable materials maintained within and among tree and other woody plant species that are of actual or potential economic having environmental, scientific and/or social values. Sustainable management of FGR is very essential, where forest trees and other species provide goods and services. Genetic diversity of trees are essential to entire forest ecosystems, since trees are 'foundation species' and they play a key structural role in the ecosystem management. There are several threats for loss of forest genetic resources. Habitat destruction/ deforestation, fragmentation, degradation, overexploitation, unsustainable harvesting, epidemics, introduction of exotics, environmental pollution and climate change are major threats for loss of biodiversity and FGR. Therefore, it is essential to protect, conserve and sustainable management of FGR for ecosystem development and for future livelihood. There are several measures/ strategies for conservation of genetic resources. Among them, *in-situ, ex-situ,* restoration and reintroduction, on-farm conservation, forest gene bank concept are the major conservation measures. Similarly, biotechnological, legal

and social/ethical strategies are also help in conservation of FGR. In this context, all these measures and strategies are discussed along with case studies as given below:

Brief Review of Research Work:

As per recent report (www.wiienvis.nic.in), total forest cover of India is 7,01,673 km^2 and it represents 21.34 per cent of the total geographic area. In India, there are 733 Protected Areas (PAs) and 18 Biosphere Reserves and they are example for *in-situ* conservation, where plants, animals and many organisms are conserved in the natural habitat.

Krishna Kumar *et aL* (2012) reported several conservation measures takenup in the country, among all, about 444 population of 74 species have been conserved in the natural forests/stands. Moreover, total 187 Permanent Preservation Plots and 54 Medicinal Plants Conservation Areas have been maintained in the country. Apart from this, total 16,821 plus trees/ Candidate Plus Trees (CPTs)/genotypes have been selected from 58 species across the country.

Manasa Bhatta (2016) reported that, in order to protect the valuable medicinal plants in the natural forests of West Bengal, efforts have been made by the forest department and total six *in-situ* conservation sites to with area of 41 ha are itablished for medicinal plants in three districts.

Anon (2015) reported that Gujarat Biodiversity Board (GBB), Gujarat iidentified inland mangrove biodiversity heritage site at Kuchchh to conserve 42 plant species. Similarly, to conserve wild mango, GBB identified natural mango forest biodiversity heritage site at Chinchali, Dangs.

Amarjyoti Borah (2016) reported importance and conservation of Indian wild orange, believed to be the progenitor of all citrus species in the world, grows at Nokrek of Meghalaya. The first gene sanctuary of the world for the *in-situ* conservation of the Indian wild orange *(Citrus indica)* is established at Nokrek of Meghalaya. Now the area may attain the status of a UNESCO Heritage Site. A section of the biosphere reserve was declared the National Citrus Gene Sanctuary after Indian wild oranges were found there.

Akshay *et al.* (2014) stated that, in our country, there are 13,720 sacred groves documented and these serve as a unique *in-situ* conservation system. The state of Himachal Pradesh is having more number of sacred groves (5,000), followed by Kerala (2,000), Maharashtra (1,600) and Karnataka (1,424).

Gunaga et al (2013) in their experiment made a comparative description of tree diversity of Kaan forests (Thick evergreen forest) and state-managed reserve forests in Sagar taluka of Karnataka. The result reveals that Kaan forests possessed higher species richness (120) as compared to reserved forests (59). They have also compared the species of evergreen, endemic, medicinal and species of economically important in both Kaan and reserved forest. It is showed that total number of species recorded to be more in Kaan forest than reserved forest that addressing need of conservation management in Kaan forests.

Katwal *et al.* (2003) documented about *ex-situ* conservation of forest genetic resources of India. As per country report there are 1202 seed production areas of priority species spreading over 18 states and managed for quality seed production. *Tectona grandis, Casuarina equisetifolia, Pinus roxburghii, Dalbergia sissoo, Acacia auriculiformis* are some priority species considered for genetic improvement and conservation.

Bisht and Ahlawat (1999) reported that, seed production areas of *Bombax cieba* (2ha), *Dipterocarpus macrocarpus* (16 ha), *Terminalia myriocarpa (11* ha) have been developed by State Forest Research Institute in different sites of Arunachal Pradesh.

Krishna Kumar *et al* (2012) compiled the studies of forest genetic resource undertaken in different parts of the country and they are compiled in country report of conservation of FGR. The data recorded for provenances/progeny tests of important species shows that species like *Acacia nilotica* (121 trails with 719 accessions), followed by *Eucalyptus* spp. (100 trails with 1417 accessions). Valuable species like *Tectona grandis* (36 trails with 917 accessions) and *Santalum album* (19 trails) have been used in tree improvement programme. As per report, in India, seed orchards have been established for 58 commercial important tree species and more seed orchards are established for *Tectona grandis* (4,572). Moreover, second generation seed orchards have been developed for species like *Casuarina equisetifolia* and *Eucalyptus* spp. Total twenty three species have been conserved in clonal banks (5463 clones of different species) established at different places. *Hevea brasiliensis* alone have 4548 clones. Other aspects of germplasm bank, cryo-preservation and seed bank established in the country are overviewed in detail.

Punia (2010) compiled the countrywide research and development activities regarding the tree borne oilseeds supported by National Oilseeds and Vegetable Oils Development Board. According to the report, 3291 Candidate Plus Trees (CPTs)/ seed sources of Jatropha have been identified and among them, 868 CPTs selected from 34 research institutes are cryo-preserved in NBPGR. Similarly, there are about 1284 CPTs/ seed sources of Karanja have been identified and about 255 CPTs are cryo-preserved at NBPGR. Similar information on Simarouba, Mahua, Kokum, Cheura, Wild apricot have been already compiled.

Vanishree Hegde *et aL* (2015) addressed importance of *on-farm* conservation in Uttara Kannada district of Karnataka representing central Western Ghats. About 23 tropical tree species have been documented in homegarden, orchard and bettaland and they serves as on farm conservation system. Most of the recorded species are fruit yielding and some of them are important minor fruits.

Gajanan *et al.* (2015) reported various aspects of *on-farm* conservation in India. Main species conserved *on-farm* are Citrus, Mango and Kokum. According to study, total 18 diversity fairs have been documented on Mango, Citrus and Kokam species from five different sites and details are discussed. Mango recorded to be more prominent species with more number of diversity fairs with different varieties. Documentation of traditional variety plays a major role in conservation. As per this study, out of 185 varieties characterized, 68 varieties have been registered.

Saikia *et al* (2012) documented diversity and conservation importance of species in homegardens. Altogether, 294 plant species representing 217 genera and 92 families have been documented from 80 studied homegardens from 17 villages in Golaghat and Jorhat districts of Upper Assam. Homegardens of Golaghat district have more number of species than Jorhat.

Pandey *et al* (2006) carried out survey in 19 homegardens in South Andaman to elucidate species structure and diversity in their floristic composition. Study reported that 9 tree species and 8 shrubs are commonly recorded in study sites.

Singh (2012) stated that Mangrove's conservation and restoration in Gujarat may be listed among the best in the world. Gujarat Forest Department, Gujarat Ecology Commission and other industries have involved in conservation of mangrove in Gujarat. Mangrove cover increased by 2.5 folds in two decades due to the successful plantation activity taken by these organizations.

Vasudeva *et al* (2008) conducted the recovery pilot project for *Semecarpus kathalekanensis,* a critically endangered, evergreen tree occurring in the fresh-water swamps of the central Western Ghats. The survival per cent of plants in introduced sites recorded to be 46.70 and 45.45 in two different sites.

Yadav *et al.* (2009) made a successful attempt to restoration of *Hubbardia heptaneuron,* a monospecific, critically endangered and endemic grass at its past and type habitats. This species is successfully conserved in 16 different type localities in western ghats.

Uma Shaanker *et al.* (2002) proposed a concept of forest gene bank that includes both *in- situ* and *ex-situ* conservation approaches for conservation forest tree species in India through different studies. *Phyllanthus* is one among them and they have recognized BRT Hills for conservation. The approach of forest gene bank concept is discussed.There are several strategies for conservation of FGR. Among them biotechnological approaches plays a major role in conservation. In this study, approaches of tissue culture, determination of sex at seedling stage, molecular diversity and cryo-preservation to enrich *ex-situ* conservation and restoration of species are discussed in detail.

Legal stipulations are helpful in conservation/ protection of biodiversity as well as forest genetic resources. Here, various acts and policies of India which are related to forest and biodiversity conservation are discussed in detail. Social approach strengthens the conservation of forest genetic resources. In the study of Soni (2008), community-based approaches have been discussed to conserve *Commiphora wightii* in Rajasthan. It is recorded that community based approaches are highly effective for conservation of endangered plants species like *C. wightii.*

Conclusion:

Forest genetic diversity provides the fundamental basis for evolution of forest tree species that provide nutritional,.vironmental and social security for livelihood. As a result of pressure on forest lands due to deforestation, degradation, climate change, other anthropogenic pressure, the great potential of forest genetic resources is at risk of being lost. Despite the enormous threats, there have been limited concentrated efforts to

address the conservation concerns of forest trees. Critical information on the status, threats and extent and distribution of genetic diversity are required for planning effective conservation strategies. Process of conservation of Forest Genetic Resources is making significant changes in the country. Overall study shows that approaches of *in-situ, ex-situ,* restoration can be used wither for conservation of individual species or habitat/ecosystem as a whole. *On-farm* conservation is very essential to protect and conserve many species which are cultivated in their farm/orchards. Scientific advances in biotechnology and legal developments, perhaps, strengthen the conservation of genetic resources. Social approach also showed significant role in conservation of genetic resources as well as biodiversity. The synergetic effort of combining *in-situ* and *ex-situ* approaches with the legal support and other strategies would resulted in more positive way in conservation and addresses many challenges effectively.

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Seminar No. 65

Speaker : **Mr. M. R. Parmar**	Reg. No. 1030314002
Degree : Ph.D Forestry (Agroforestry)	Course No: FOR-691
Major Adviser: **Dr. A. Arunachalam**	Venue: Conference Hall
Minor Adviser: **Dr. S.K. Jha**	Date: 01/10/2016

MANGROVE FORESTS: STATUS, THREATS AND THEIR MANAGEMENT

India with a long coastline of about 7516.6 km, including the island territories, had a mangrove cover of about 6,749 km^2, the fourth largest mangrove area in the world. However, a recent assessment shows that India has a total mangrove cover of only 4,628 km² or 0.14% of the country's land area, 3% of the global mangrove area, and 8% of Asia's mangroves., of which about 60% is along the east coast (Bay of Bengal), 27% is along the west coast (Arabian Sea) and the remaining 13% is in the Andaman and Nicobar Islands. India's mangroves can be broadly categorized into deltaic, backwater-estuarine and insular types according to Thom's classification of estuary habitats. Mangroves in India are unique in terms of their extent, variability and biodiversity (Sahu *et al.,* 2015). However, there has been an overall continuous decline in mangrove forests caused by conversion to agriculture, aquaculture, tourism and urban development will increase the threat to human safety and shoreline development from coastal hazards such as erosion, flooding, storm waves, cyclones and tsunami, as recently observed during 1999 super cyclone in Orissa and 2004 Indian Ocean Tsunami (Sahu *et al.,* 2015). Various techniques for the conservation and management of mangrove forests have been applied around the world. Detailed guidelines have been devised by a number of international organizations to help their members develop more effective mangrove management plans. These organizations include, the United Nations (UN) Food and Agriculture Organization (FAO), International Tropical Timber Organization (ITTO), the Ramsar convention, and the International Society for Mangrove Ecosystems (ISME) (Haille *et al.,* 2015).

Brief review of research work:

According to Indian State Forest report of various states and union territories, the mangrove cover was gradually increased in India with time up to 2001 & 2003 and then after little decrease in area. The very dense mangrove (990 km^2) and moderately dense mangrove (700 km^2) were observed in West Bengal state whereas open mangrove (933 km^2) was found maximum in Gujarat state.

Sahu *et al*. (2015) noted maximum area under restored mangrove (1978 ha) in Andra Pradesh.

Ivan *et al*. (2001) reported maximum percentage losses of mangrove forest (38 %), annual rate of loss (2251 km^2/year) and percentage of original area loss/year (3.62 %) in America while all these parameters was found minimum in Australia.

Bhatt *et al*. (2009) registered seven species of mangroves *viz., Avicennia marina*, *Sonneratia apetal, Acanthus ilicifolius, Rhizophora mucronata, Ceriops tagal, Bruguiera cylindrical* and *Aegiceras corniculatumin* in Purna estuary of South Gujarat which makes Purna estuary one of the most diverse mangrove patch in state. They also recorded various associates of mangroves in salt marsh helophytes of Purna estuary.

Kumar and Thivakaran (2013) recorded maximum mature trees (3559 nos/ha), recruitment class (18324 nos/ha) and regeneration class (41236 nos/ha) at Kharo mangrove in station III, V and IV, respectively.

Untawale and Wafar (1998) studied floristic diversity in mangroves of Karnataka and stated that *A. officinalis, Acanthus spp., R. mucronata, A. marin* and *Acanthus ilcifolious* were found dominant species of Kali Nadi, Belamdar Nadi, Aghanashini river, Kumta river and Sharavati river, respectively.

Hein (1999) reported maximum encroachment of shrimp farms on dense mangrove, sparsh mangrove and agricultural lands between 1989 and 1999 in Godavari delta.

Roy and Krishnan (2005) studied impact of Tsunami on mangrove stands of Andaman and found that 80% of *Rhizophora spp.* were affected in the high saline micro habitat and died due to continuous submergence and *A. marina* in South Andaman. In case of middle Andaman, mangroves are healthy and not affected by Tsunami. However in North Andaman, mangrove roots remain exposed even during spring tide.

Sahu *et al.* (2015) stated that agriculture, prawn seed collection, reduction in fresh water flow, natural calamities, encroachment, invasion of alien species, grazing, over exploitation of mangroves, developmental activities, coral reefs degradation, urbanization, industrialization are the major threats for mangrove grown area.

According to NSAP (2008) wherever tidal amplitude is low, the preference for restoration should be the canal bank planting technique with fish bone design; and, wherever tidal amplitude is high, the technology adopted should be seedling planting and direct seed sowing in the mud flats.

Haille *et al*. (2015) reviewed timeline of coastal zone management and reported that implementation of ICZM that incorporates ecosystem based multiple use and adaptive management are the recent management trends for mangrove conservation. They also gave various guidelines and key elements suggested by FAO, ITTO, Ramsar Convention and ISME for primary management of mangrove ecosystems. They further overviewed mangrove protection policies, implementation of ICZM and international involvement in five countries for mangrove conservation.

Conclusion:

The mangrove cover was gradually increased in India with time up to 1999 and then after little decrease in area. In India the highest area of mangrove was found in West Bengal. In case of world, it was found maximum in Asia. The agriculture, prawn seed collection, reduction in fresh water flow, natural calamities, encroachment, invasion of alien species, grazing, over exploitation of mangroves, developmental activities, coral reefs degradation, urbanization, industrialization are the major threats for mangrove grown area. The implementation of ICZM that incorporates ecosystem based multiple use and adaptive management are the recent management trends for mangrove conservation.

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Seminar No. 66

Speaker : **Mr. J.B. Bhusara**	Reg. No. 1030314001
Degree : Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Advisor: **Dr. Manmohan J Dobriyal**	Venue: Conference Hall
Minor Advisor: **Dr. N.S. Thakur**	Date: 29/04/2017

ECONOMIC ANALYSIS OF AGROFORESTRY SYSTEMS

Agroforestry has the potential to improve livelihood as if offers multiple alternatives and opportunities to farmers to improve farm production and income and also provides productive and protective function to ecosystems. Economic analysis is the most important factor that will determine the value and feasibility of agroforestry to the land owner. For the economic analysis the different methods developed on the different criteria to evaluated the different agroforestry systems.

Brief review of research work:

Sharma *et al.* (2007) reported that traditional agroforestry (Cardamom AFs) in the eastern Himalaya region is an efficient management system where ratio of output to input is more than 13 as compared to rainfed agriculture (1.85). Cost benefit analysis showed that the cardamom agroforestry is profiting the farmers by 5.7 times more as compared to the rainfed agriculture.

Rasul and Thapa (2006) found that NPV of Agroforestry was much higher than that of Jhum. Similarly the B-C ratio and return to labour was also higher in the Agroforestry system than the Jhum system.

Kassa (2015) studied fruit tree based agroforestry land use in Ethiopia and found that the combination of fruit trees with perennials like Enset and Coffee, generated highest NPV (7,31,608.35), BCR (3.43) and AEV (80600.28) than the monocropping systems.

Wulan *et al.* (2006) assessed economic of various rubber based farming systems and revealed that the traditional system (local jungle rubber) is not profitable, indicated by negative values for return to land (negative Rp.1,073,000 ha^{-1}) and the system also not attractive as return to labor lower than the real average wage rate in the study area (Rp.17,907 compare to Rp. 20,000). Rubber based Agroforestry technologies are profitable, indicated by positive values for return to land (varied between Rp.2,864,000 – Rp. 18,316,000)

Chaudhry*et al.* (2007) compared the economic return from Poplar- wheat, fodder maize intercropping to monoculture and found that the intercropping the wheat and fodder-maize gave highest net benefits (51,495 Rs/ha) was observed in the D_2 (3.66 x 9.10 m i.e. 305 trees/ha) while lowest net benefits (-10,904 Rs/ha) was observed in sole wheat, fodder maize treatment.

Kibri and Saha (2011) studied the Pineapple, Lemon, Banana based agroforestry practices and analysed that the banana based agroforestry is financially more profitable with Net Present Value (23,35,555 TK) than other two systems, while the Benefit- Cost ratio BCR (4.21) is higher in pineapple based agroforestry and also in Lemon agroforestry system (4.05) at the 10 to 12 % interest rate.

Anjum *et al.* (2011) compared the agriculture and agroforestry land use systems on the basis of average expenditures and revenues per year and revealed that the average gross benefits (2,69,081.5), Net Present worth (1,51,098.5) and Return on investment (128) was recorded highest in Sugarcane + tree as compare to sole Sugarcane.

Mehta and Leuschner (1997) found that Coffee + Leaucaena system was more profitable in NPV (2,617.9), EAI (384.2), IRR (62.6 %), NPVP (3,842.1) at 10 % rate as compare to sole Cyoress, Coffee, Coffee + Poro and Coffee + Eucalyptus.

Bari and Rahim (2012) reported that Coconut + Guava + Aloevera, Asparagus, Misridana gave highest Net return (2,05,229, 2,08,048 and 1,88919, respectively) and BCR (3.54, 3.21 and 5.06, respectively) as compare to Coconut + Lemon + Aloevera, Asparagus, Misridana systems and sole Crops.

Affendy *et al.* (2013) observed that intercropping of *T. grandis* with *Salacca zalaca* gave highest NPV at (5 %) of intercropping (70,471.30) and B- C ratio (2.75), LER (1.37) and 23.68 % of IRR and have a shorter payback period (13 years) as compare to the sole cropping.

Raddad and Luukkanen (2007) reported that intercropping of agriculture crop with *Acacia senegal* (5 x 5 m) with sesame is more efficient in terms of utilization of available resources than mono-cropping and present highest LER 2.29 in the year 2002 as compared to previous years.

Borrell *et al.* (2005) found that the Silvoarable system was more profitable than the pure plantation moreover Walnut systems was more profitable than Poplar and Wild cherry System. The LER (1.55) was recorded highest in walnut silvoarable systems.

Tang (2011) studied the homegardens and found that the percentage of household income from homegardens increased from 38% for small homegardens to 48% for medium homegardens and 70% for commercial homegardens.

Momen *et al.* (2006) found that average benefit-cost ratios was greater than one, net present values were positive and internal rate of returns were more than 10 %. Long term investment on horticulture and timber tree species was highly profitable if species like *Artocarpus heterophyllus, Cocos nucifera, Tectona grandis* and *Swietenia macrophylla* were planted.

Dhanya *et al.* (2016) stated that the Agrisilviculture system (Mulberry + Teak) gave higher NPV (10.50 @ 7 % and 4.98 @ 13 %) and B:C (2.10 @ 7 % and 1.76 @ 13 %) ratio as compare to other agroforestry systems and plantation of *Eucalyptus hybrid*.

Chand *et al.* (2015) studied different forestry plantation of acacia and eucalyptus as well as agroforestry based system and concluded that Eucalyptus + Geranium Agroforestry gave highest BCR (4.25), NPW (86369), IRR (59 %) criteria as compare to acacia and eucalyptus sole and acacia and eucalyptus based agroforestry systems.

Rani *et al.* (2015) observed that Agrisilviculture land use system under wheat and poplar was viable and more profitable than other cropping systems with highest gross return (7,34,982), net return (5,37,977) and B-C ratio (2.53).

Divya found that the Casuarina + cowpea gave highest net return (400 Euros/ha and 472 Euros/ha, respectively) and B:C ratio (1.76 and 1.84, respectively) in both spacing (1.5 x 1.5 m and 2 x 1 m). However, bhendi and groundnut were found to be the profitable intercrops for Casuarina based agroforestry systems @ 2 x 2 m and 2 X 1 paired row spacing of Casuarina.

Rathore (2013) stated that the mango based agri-horticulture model intercropping with cowpea gave higher NPV (5,068 USD) and BCR (2.67) as compare to other intercrop under mango based systems.

Das *et al.* (2011) found that anola + turmeric based Agri-Horticultural system gave higher BCR (6.29) and net return (4,63,665) as compare to other anola based systems (anola + ginger, anola + arbi) and sole anola.

Buvaneshwaran *et al.* (2010) reported that the sole plantation of Casuarina gave highest net income (83,250), NPV (83,666) IRR (48.91), B:C ratio (1.45) than the Eucalyptus, teak, Anola plantation as well as Casuarina + cowpea based system.

Viswanath *et al.* (2010) found that 15 years block plantation of Sandal recorded highest NPV (Rs. 26,83,088/ha and 12,52,693/ha, respectively), B:C ratio (4.4 and 3.3, respectively), IRR (33), EAI (Rs. 3,52,756/ha and 2,14,232/ha, respectively), LEV (Rs.35,27,558/ha and 14,28,212/ha) at the discount rate of 10 % and 15 % as compare to the Sandal based agroforestry practices.

Awasthi *et al*. (2005) revealed that the mango based multi species cropping systems gave more Net returns (3,99,635 Rs/ha) as compare to the mono crop cultivation of mango.

Ram and Kumar (2009) reported that Annona + *Stylosanthes hamata* system gave more net return (13,710) and B:C ratio (1.52) than the Annona + *Stylosanthes scabra* system (11,426 and 1.27, respectively) .

Mohan (2004) indicated that agroforestry systems were economically profitable for the small-farm household, and were resilient to shifts in the prices of labor or commercial crops. Homegarden cultivation was estimated to be the better economic option for such landowners, even considering the opportunity costs for land and labor.

Conclusion:

Economic analysis can serve important role in encouraging agroforestry dissemination. Generally economic analysis of agroforestry systems is based on gross income, net realization, net present value, internal rate of return, net present worth, annual equivalent value, benefit cost ratio, harvest index and land equivalent

ratio. Among all these parameters land equivalent ratio and net realization are precise parameters but in practice BCR, NPV and IRR are commonly used for economic analysis of various agroforestry systems.

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Seminar No. 67

Speaker : **Mr. H.T. Hegde**	Reg. No. 1030314002
Degree : Ph.D Forestry (Forest Genetic Resources)	Course No: FOR-692
Major Advisor: **Dr. R.P. Gunaga**	Venue: Conference Hall
Minor Advisor: **Dr. S.K. Jha**	Date: 29/04/2017

GENE FLOW IN FOREST TREES: IMPLICATIONS FOR FOREST GENETIC RESOURCE MANAGEMENT

Evolutionary biologists have long been interested in gene flow because it is one of the main factors determining the genetic architecture of populations, along with mutation, drift, and selection. Gene flow can be defined as "transfer of genetic material between populations resulting from the movement of individuals or their gametes". Gene flow might be considered either beneficial or deleterious from the point of view of a conservation geneticist or a tree breeder (Burczyk *et al.*, 2004). From an ecological standpoint, gene flow is one of the key factors determining composition of ecosystems and responses to disturbance (Connell and Slatyer, 1977). It is also important to describe the patterns of gene flow in terms of distances and rates, although accurate estimates of gene flow among populations are difficult to obtain. Gene flow *via* seed and pollen is a primary determinant of genetic and species diversity in plant communities at different spatial scales (Christopher *et al.*, 2008). Gene flow occur through many agents *viz.*, wind, water, animal and others; moreover, this process is influenced by many factors pollinators, seed dispersers, phenology of the species, out-crossing behaviours, inbreeding depressions and others. All these points are discussed in the seminar with case studies by highlighting strategies for effective management of forest genetic resource.

Brief Review of Research Work:

Christopher *ei al.* (2008) reported that small insects disperse pollen over smaller distances than do large bees; furthermore, maximum pollen dispersal often does not exceed 300 meters. Interestingly, bat is recorded as potential longer dispersal agent.

Sabna Prabha *et at* (2011) noted that in natural teak forests of Peechi, Kerala, gene flow through pollen acts over longer distances than through seed dispersal, since the main range of pollen dispersal distance was 151-200 m and that of seed dispersal was 50-100 m.

Ismail *et at* (2012) reported the estimates of historic gene dispersal (a) in adult trees which ranged from 171 to 804 m depending on the value of D applied (density); however, these values were more similar in juvenile trees indicating no significant difference among cohorts.

Sharma and Khanduri (2007) draw the conclusion from their experiment that the scattering of pollen grains of *Plums roxburghii* was not uniform in all studied directions *viz.* uphill, downhill and horizontal directions. Pollen frequency declined rapidly as the distance from the source increased with the highest density values within 50100 in.

Sharma and Khanduri (2012) observed a significant dispersion of pollen grains of *Cedrus deodara* in different directions and it was up to 48 m in the uphill direction, 192 in in the downhill direction and 96 In in the horizontal direction. They suggested that minimum isolation strip of 192 m may be considered while managing *C. deodara* seed orchard.

Christopher *et al.* (2008) found that most of the pollinators for the tree species of tropical rain forest of south America are insects, although bats and humming birds also have a vital role. Various dispersal agents reported like wind, gravity and animals involved in gene flow are elaborated. Study highlighted about the importance of both pollinators and dispersers in the processes of gene flow.

Nama and Choudhary (2013) investigated the per cent contribution of dispersal mode in 103 different species in Mukundara Hills National Park, Kota, Rajastan and reported that dispersal through zoochory (68 %) was dominant in woody plants as compared to anemochory (18 %) and autochory (14 %).

Seidler and Plotkin (2006) recorded seven dispersal syndromes *viz.* ballistic, gravity, gyration, wind, animal (small fruit size), animal (medium fruit), and animal (large fruit) in tropical forest of peninsular

Malaysia. Maximum species (N=209) shows animal (small fruit size) as dispersal syndrome, however, ballistic syndrome observed to be minimum.

Ganesh and Davidar (2001) reported about the gene flow agents of the wet forests of Western Ghats. 60 per cent of birds are the principal gene carrier of the region; however, the role of mammals also noted especially in case of large fruits.

Burczyk *et al.* (2004) overviewed the estimation of pollen-mediated gene flow immigration into populations of forest tree species (Natural population, Seed orchard, Plantation) based on genetic exclusion analyses. The study showed that effective pollen immigration into natural populations of wind-pollinated species is usually substantial, especially when studied in sample plots located within larger continuous forest stands. The pollen immigration varied from 6.5 (Natural population of *P itillS flexilis)* to 70 per cent (Seed orchards of *Quercus robur* and *Picea abies)* among different species. In fact, pollen immigration (6.5 %) in population of *Pinus flexilis* is well isolated from other scattered stands (>2 km) and a large continuous population (>100 km) of the same species.

Anon. (2017) studied the pattern of seed dispersal and seedling survival in *Bombax malabarica* L., a wind-dispersed tropical species. it is reported that seed density showed a typical leptokurtic distribution where the seed density decreases with the distance away from the tree. Interestingly, Tree height determines the slope *i.e.,* the proportion of seeds falling close to the parent tree are high in shorter trees than taller ones. Further, seed shadow distance (the distance over which seeds dispersed) and height were also positively correlated.

Tadwalkar *et al.* (2012) documented different dispersal modes of woody species from the northern Western Ghats. Results shows that, among 10 diverse families studied, only three families *viz.,* Fabaceae (5 species), Meliaceae (1 species) and Mimosaceae (two species) have noted as wind dispersal mode in combination with autochory and zoochory. However, they also reported that, Bignoniaceae, Lythraceae and Malvaceae, only represented by a few species, were exclusively anem'ochorous.

Ragavan *et al.* (2016) assessed the similarity among of Indian mangrove habitat in India. Result showed that mangrove habitats of Lakshadweep, Diu and Puducherry exhibited low similarity than other 10 mangrove habitats in India. There are two major clades formed in the cluster, the first Glade formed by mangrove habitats of West coast, Tamil Nadu and Andhra Pradesh and the second one is formed by mangrove habitats of Andaman & Nicobar Islands (ANI), Odisha and West Bengal. The close similarity between ANI and mangrove habitats of West Bengal and Odisha indicates the gene flow (dispersal of propagules/seeds) between the east coast of mainland India and ANI.

Parolin *et al.* (2013) compiled the data base of seed dispersal mechanism in forest trees. It is reported that 27 per cent of tree species have dispersal linked to water. The data with experimental evidence focused on water-related species obviously show a higher percentage of hydrochory (42%).

David *et al.* (2015) studied the major frugivores in Coastal Tropical Dry Evergreen Forests of southern India and reported about the ten birds and eight mammals visits more than ten species of trees and involved in their gene movement. It is also recorded that many birds and mammals largely depends on seventeen important fruit trees and five shrubs for their food indicating potential role of animals in gene flow among these 22 species.

Balasubramanian *et al.* (2011) carried out a study to assess the role of different frugivores in the seed dissemination of sandalwood tree in Tamil Nadu. Results revealed that the highest proportion of feeding visits was contributed by Red-whiskered Bulbul (20.30%), followed by White-headed Babbler (17.51%).

Kumar *et al.* (2015) reported that *in Calophyllum apetalum* species dispersal by anemochory is observed to be up to 100 m from the tree canopy; further, seed material can flow in water to several km distance regenerates and establish. It is also reported that many medium to large herbivorous animals were involved in movement of genetic material.

Cady *et al.* (2010) concluded that reduction of natural population of black pine in southern France occurred due to the anthropogenically induced gene flow of alien provenance.

Silva *et al.* (2008) reported about the effects of selective logging on the gene flow and genetic diversity of the population. The harvest of 61 per cent of the adult trees caused the loss of three alleles in the reproductive population due to the lack of gene flow.

Levey *et al.* (2002) suggested that there is a threshold of bat density, below which there is no dispersal occurs, since all feeding bats can be accommodated within the fruiting trees.

Conclusion

Trees are capable of long-distance gene flow, which can promote adaptive evolution in novel environments by increasing genetic variation for fitness. Gene flow is a major determinant of impacts of forest tree plantations on surrounding populations and ecosystems. The overall studies shows that there are several factors such as phenology, habitat, ecosystems, species life form, varieties of agents significantly influence on gene flow within specific time and place. Trees disperse their gene either through pollen or with the help of fruits/seeds. It occurs through many ways/ agents independently or in combination. Among them, zoochory is the major way through which the flow of gene takes place in forest and large number of pollinators and dispersers involved in the process. However, more comprehensive picture of gene flow and the genetic systems of forest trees will emerge from the increasing number of studies on actual gene flow. Information on mating system and gene flow are relevant while developing management strategies for FGR.

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Seminar No. 68

Speaker : **Mr. M. R. Parmar**	Reg. No. 1030314004
Degree : Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. A. Arunachalam**	Venue: Conference Hall
Minor Adviser: **Dr. S.K. Jha**	Date: 06/05/2017

AGROFORESTRY SYSTEMS FOR ARID AND SEMIARID ZONES

Of late, the importance of agroforestry is increasingly being realized from all corners owing to its multifaceted role in sustainable production, soil health, biodiversity conservation, employment generation, drought proofing, natural resource conservation and ecosystem services. Agroforestry is a unified land-use system involving all disciplines. The area under agroforestry in India is estimated as 25.3 million ha, which is 8.2% of the total geographical area of the country (Dhyani *et al*. 2013). There is scope of increasing the area under agroforestry in future by another 28.0 million ha, which can be brought from cultivable fallows, pastures, groves and rehabilitation of problem soils. Researchers and planners are increasingly recommending agroforestry systems as a sustainable form of land use for augmentation of biomass production from agricultural systems.

Brief review of research work:

Rai *et al*. (1998) recorded that the dry biomass of main bole (trunk) (18.73 t/ha) and dry leaf production (3.81 t/ha) were recorded significantly maximum in *A. procera* than rest of ten MPTs under study. However, dry yield of branches (30.49 t/ha), total biomass (35.67t/ha) and productivity were registered maximum in *D. sissoo*.

Bhatia and Kanaujia (1995) revealed that pearlmillet and barley in association with wider alley (6.0 m) of Leucaena produced significantly higher grain (7.0 and 17.6 q/ha, respectively) and stover yield(60.9 and 36.73 q/ha, respectively) over narrow alley (4.0 m) of crop.Moreover, in case of intra row spacing, grain (7.2 and 18.13 q/ha, respectively) and stoveryield (62.48 and 37.29 q/ha, respectively) were higher under 0.5 m intra-row of Leucaena followed by 1.0 m spacing, whereas lowest under 1.5 m spacing.

Yadav*et al.* (2005)observed lower wheat yield under the tree species as compared to open fields. Tree species affected wheat yields differentially.*A. nilotica* decreased wheat yields most prominently followed by *D. sissoo, A. leucophloea* and *P. cineraria.*

Meena *et al.* (2005) revealed that progressive increases in Ardutree density caused significantly higher production of dry leaf fodder, fuel wood yield and total biomass production per hectare as compared to lower densities during the study. The 100 tree/ha registered higher dry leaf fodder (3.10 t/ha), fuel wood yield(2.88 t/ha) and biomass production (5.96 t/ha) over 25, 50, and 75 trees/ha, respectively.However, the maximum leaf and fuel wood yield production was obtained in 1:2 ratio of Cenchrusand Cowpea, this combination registered significantly higher dry fodder (1.93 t/ha), fuelwood yield (1.70 t/ha) and total biomass production (3.61 t/ha) as compared to sole Cenchrusand Cowpea.

Qaisar *et al.* (2007) observed significant differences in growth of trees under the agroforestry system. The tree height (6.35 m) was slightly higher in combination plots (Tree+ Fodder) whereas, the DBH (4.68 and 4.67 cm, respectively) was observed more in Catalpa and Populus pure plots as compared to tree + fodder crop. However, in terms of fuel wood, tree fodder and total biomass the tree + fodder crop combination gave the higher production.

Dar and Newaj (2009) reported that biomass of herbaceous layer increased with the advancement of the crop growth. However, the biomass of herbaceous layer was highest in 70% canopy pruning and lowest in control.

Bhatt *et al.* (2006) reported that the accumulation of chlorophyll ‘a’, chlorophyll‘b’, sugar, starch, crude protein and plant height in both the grasses were higher under tree canopies and the maximum accumulation of chlorophyll ‘a’ in these grasses indicates their shade adaptation. Maximum rate of photosynthesis, transpiration rate and stomatal conductance were observed in grasses in open field which reduced sharply under the shade of canopies.

Tewari *et al.* (2014) reviewed production function of *P. cineraria* and *Z. nummularia* based traditional extensive silvi-pastoral systems of different habitats. *Heloxylon salicornis* was prominent and maximum browsed (11.4 q/ha) herbaceous species available in alluvial plains.

Saroj *et al.* (2003) revealed that different spacing have marginal effect on the yield of groundstorey crops during the initial stages. Plant spacing had marginal effect on the yield of *kharif* crops as groundstorey component however slightly higher yield was recorded under sole cropping in both Groundnut and Clusterbean. In *Rabi* season also, the different spacing had marginal effect on the yield of groundstorey components. In case of Indian aloe the highest average yield (55.62 q/ha) was recorded under sole cropping.

Dhillon *et al.*(2003) revealed that pyramidal and inverted pyramidal both types of shelterbelts reduced the wind velocity and maximum wind reduction was at 2 H (36.5 %) whereas, wind speed increased as the distance from the shelterbelt increased. The percent reduction in all the distances was recorded more in inverted type of shelterbelt. The soil moisture content increased with depth in soil profile in leeward side of both shelterbelts. The SMD and DR at different distances were higher in pyramidal than inverted pyramidal type of shelterbelt.

Prasad *et al.* (2009) stated that shelterbelts had considerable influence soil characteristics of sheltered area on leeward side as it increase in soil organic carbon (0.11 %) and electric conductivity (0.40 dSm^{-1}) and reduction in soil reaction (7.84) near the tree belt.

Pandey *et al.* (2002) observed increased organic carbon (0.590 %), available N (210.37 kg/ha), P (17.45 kg/ha), and K (235.70 kg/ha) under Neembased plantation over control. Increment in organic carbon and available N, P, and K was lower in 15-30 cm soil depth as compared to 0-15cm. Soil pH (6.90) was slightly lower in both the plantation as compare to control (7.43).

Nandal and Kumar (2010)found that the yields of all the winter season crops were almost identical both in association with Meliaas well as control. However, from fifth year onward, the yield of all the winter season crops declined under Melia. The decrease was minimum in Berseemand maximum in Wheat.

Kaushik *et al.* (2002) revealed that mean net returns of all the crops were higher under sole cropping but the agri-silvi-horticulture systems of pearlmillet + *D. sissoo* + *M. alba*, pearlmillet + *A.indica* + *M. alba*, raya + *D.sissoo*+ *M.alba* and chickpea + *A. indica* + *M.alba* showed apparently more returns as compared to sole cropping. Silvi-horticulture systems of *D.sissoo* + *M.alba* gave maximum net returns (Rs. 2259/ha) followed by *A.indica* + *M.alba*. Among all the agri-silvi-horti systems, Chickpea + *A.indica* + *M.alba* recorded maximum net return of Rs 18829/ha/year.

Thakur and Dutt (2003) observed that the thousand grain weight (46.6 g), total plant yield (427.7g/m^2), grain yield (105.8 g/m^2) and harvest index (24.7 %) was comparatively higher at wider hedgerow spacing of 2.5 m during the study as compared to closer spacing and distance from hedgerows.

Sharma (2010) suggested that maximum returns were provided by Moongin Henna plantation at 30 cm X 250 cm spacing (Rs.44955/ha) followed by Cowpea in Henna plantation at 30 cm X 250 cm spacing (Rs. 38791/ha) as intercropping systems. However returns received from sole cultivation of Henna at 50 cm x 50 cm were found very meager (Rs.17213/ha).

Conclusion:

Pearlmillet and barley in *Leucaena lecocephala* based agroforestry system, Wheat + *P. cineraria* based AFS,*Ailanthus excelsa* based AFS, Catalpa + Fodder crops based AFS, *Albizia procera* based agri-silvuculture systems, Silvipastoral systems, *Haloxylon salicornicum* based silvipastoral systems, Ber based agri-horticultural system are suitable agroforestry systems for semiarid and arid zones of India, since these systems provides more yield and biomass for livelihood of semi arid and arid regions. Pyramidal and inverted pyramidal shelterbelts reduced wind velocity and increase soil moisture depletion and depletion rate in semi arid and arid regions. Neem and Melia based agroforestry systems increased soil fertility status by decreasing harmful chemicals.

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Seminar No. 69

Speaker : **Mr. R. L. Sondarva**	Reg. No. 1030314005
Degree : Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. M. B. Tandel**	Venue: Conference Hall
Minor Adviser: **Dr. V. M. Prajapati**	Date: 06/05/2017

ROLE OF APICULTURE IN AGROFORESTRY

Apiculture fits in very well to small- scale farming systems. Apiculture does not require land to be owned and/or rented and soil fertility is not an issue to consider. Feed is also not an issue as they forage on resources: nectar and pollen. In other words Apiculture does not compete for other resources needed by livestock and crops. Bees complement crops with their pollination of farmed crops and this in turn can increase crop yields. Some crops, for example that benefit from pollination services are sisal, cashew, papaya, coconut, oil palm, citrus, sunflowers and clover. Some of these also provide to be good nectar sources for bees. Many of the inputs required for Apiculture can be sourced and made locally and do not impinge on other farm activities and required investments. Products that derive from a Apiculture enterprise use little or any farm inputs, apart from labour in harvest and processing periods. Apiculture is being practiced in orchards, home gardens, piantations, and many agroforestry systems including coconut, coffee, pineapple, and others. Beekeeping is also a relatively low-impact activity that can increase local peoples income from native forest or conservation areas. Apiculture can be practiced successfully on a part-time basis, and yields a wide array of high-value products that can increase a farmer's income by 40-60%.

Brief Review of Research work:

Mattu and Hemraj (2013) found that flowers pollinated by honeybees sites produces maximum fruit set (28.83, 27.24 and 20.08 %, respectively in Shilaroo, Matiana and Narkanda) in Golden Delicious apple as compared to other varieties. In case of fruit drop, the maximum value was recorded in Golden Delicious with no insect pollinator (Control) (36.23, 37.80 and 38.67, respectively in Shilaroo, Matiana and Narkanda).

Mushtaq and Bilal (2016) revealed that controlled release of three hive units in apple orchard with 10 per cent pollinizer ratio showed significantly better results both quantitatively; fruit set (70.07%), fruit drop (10.49 %), seed number (9.373 ± 0.084), fruit yield (303.7 kg/tree) and qualitatively; fruit size (78.733 ± 0.255

mm), fruit diameter (77.732 ± 0.687 mm), fruit weight (237.285 ± 5.702 g), fruit volume (250.476 ± 3.904 ml) and fruit colour (98.95%) as compared to naturally pollinated orchards with 10% pollinizer proportion. Similarly, controlled release with three hives in orchard with 5 % pollinizer proportion also gives a standard quality fruit (size; 72.744 ± 0.792 mm and diameter; 72.595 ± 0.184 mm) with a good commercially profitable yield (256 kg/tree) over naturally pollinated orchard (5% pollinizer proportion).

Bhagat and Mattu (2013) found that there was no significant difference in the fruit set in different experimental designs (honeybees pollinated flowers, open pollinated flowers and in control) in varieties like Royal Delicious and Redicious of apple. Similarly, they also noticed some difference in the fruit drops of self-incompatible varieties between open and honeybees pollinated flowers but it was not significant. In Golden Delicious and Red Gold, the qualitative pollination showed that weight, length, breadth, volume and number of seeds per fruit developed were significantly maximum in honeybee pollinated flowers and minimum in fruits developed under control experimental conditions in all the three orchards. Whereas, in Royal Delicious and Red Delicious varieties, the weight, length, breadth, volume and number of seeds per fruit were significantly more in fruits developed from honeybees pollinated flowers than in fruits from open pollinated flowers.

Sharma *et aL* (2004) stated that fruit set was recorded significantly higher in the apple orchards with sufficient pollinisers as compared to the pollinisers deficient orchards.

Souza *et al.* (2004) reported higher number of fruits (23.0), fruit mean weight (180.21 g), height (7.20 cm), diameter (6.80 cm), pulp thickness (4.82 mm) and number of seeds per bud (1 seed/bud) of sweet orange in uncovered treatment than in the covered treatment.

Vicens and Bosch (2000) observed more number of visit (84), fruits (23), fruit set (27.4 %), seeds/fruit (3.7), legitimate visits (54) and fruit set of legitimate visit (27.4 %) of apple by *Osmia cornuta* than *Apis mellifera.*

Pratap (1997) reported higher number of fruits/plant/picking (3.4 ± 0.4), weight per fruit (7.1 + 0.7 g) and percentage of misshapen fruits (12.6 %) in bee pollinated strawberry with 112.3 and 21.4 percent increase over control and open pollinated as compared to open pollinated.

Sasaki *et al.* (1998) found higher number of fruit dropped / panicle (164.0 + 20.4), initial fruit set (24.4 %), embryo formation (61.8 %), seed formation (100.0 %) and fruit weight (328.2±38.2 g) of mango cv. Irwin in pollination as compared to no pollination.

Sapir *et al.* (2007) recorded highest number of bees per tree (8.1) and total yield (84.3 kg/tree) of Japanese Plum in the sequential introduction (SI) treatment while the total number of colonies/ha (5), fruit set (15.8 %) and large fruit (57 mm) were found maximum in doubling colony destiny on the number of bees.

Raju and Rao (2002) compared the pod-set rate in controlled and open-pollination treatment in *Acacia sinuata* and found that the open-pollination (inflorescences tagged and followed for pod-set) yielded highest number of flower pollinated (34,272) and flower per pod (833) as compared to rest of the treatments while percentage of pod set (96 %) was noted in xenogamy.

Howpage *et at* (2010) reported significantly higher mean yield per vine and mean number of fruit per vine of Kiwifruit in SP vines than those recorded for NB vines. Furthermore, fruit grading data showed that vines caged with honey bees during the flowering season (i.e. BS) produced significantly higher numbers of small fruit between 70 and 89 g, and a lower number of larger fruit between 90 and 109 g and >110 g weight groups compared with the SP vines. The NB vines not only produced significantly less fruit per vine than BS and SP treatments, but also a significantly higher number of fruit that were <50 g. .

Gad Ish (2009) reported higher average fruit set percentage (79.4 %) and size of fruits (50.3 mm) of passion fruit in directed honeybees pollination as compared to bumblebees and hand pollination.

Naess and Chagnon (2011) noted significantly maximum yields (34 kg/ ha) and (130 fruit/pot (28 m^2) of Cloudberry from plots at sites with bee hives averaged as compared with (12 kg/ ha and 50 fruit/pot (28 m^2, respectively) from control sites. Fruit size was also better at sites with bee hives than at control sites but the observed differences were not significant.

Patil and Pastagia (2016) revealed that bee pollination with *Apis cerana* significantly increased mean number of filled seed/umbel (54.03), per cent seed set (69.51 %), yield (14.57 q/ha), 1000 seed weight (5.68 g) and seed germinath (75.91 %) of Coriander followed by open pollination and pollination without insects (PWI).

Shankar and Abrol (2016) compared the seed yield and yield parameters in different oilseed crops pollination with bees and without bees and revealed that all the seed yield and yield parameters of all oilseed crops were.recorded maximum in crop pollination by bees as compared to pollination without bees.

Goswami and Khan (2014) observed highest pod/plant (142.83) and pod percent (83.42 %) of mustard in open pollinated plots followed by bee pollinated and caged pollinated.

Wahab *et al.* (2011) found that open pollinated produced highest mean number of flowers/plants (4,030.16), percentage of pod set (82.31 %), number of seeds/plants (3,528.88), weight of seeds/plants (7.99 g), weight of 100 seeds (0.24 g), weight of seeds/m^2 (280.80 g) and calculated seed yield/feddan (1,119.2 kg) of *Pimpinella anisum* while the highest mean no. of umbels/plants (41.33) and number of flowers without pod set (2709.4) was recorded in honeybee pollinated and insect inclusion plots, respectively.

Conclusion:

All fruits, oilseed and vegetable crops need to be pollinated in order to be productive. Apiculture is very effective tool for fruit, oilseed and vegetable crops by increasing fruit and pod set, fruit size, fruit weight, yield and quality of parameters. The integration of Apiculture into agroforestry systems improves crop yield dramatically. Properly managed apiculture resulted in larger, well-formed fruits, berries, vegetables, nuts, and seeds. At the same time, the honey and a wide range of other products produced by apiculture are potential sources of additional income.

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ACADEMIC YEAR : 2107-18

Seminar No. 70

Speaker : **Mr. Dholariya Chintan A**. Reg. No. 2030316001
Degree : M.Sc. Forestry (Agroforestry) Course No: FOR-591
Major Adviser: **Dr. L.K. Behera** Venue : Conference Hall
Minor Adviser: **Dr. R.P. Gunaga** Date: 16/09/2017

PRODUCTION POTENTIAL OF POPLAR BASED AGROFORESTRY SYSTEM IN INDIA

Agroforestry is a dynamic, ecologically based, natural resources management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels (ICRAF). Agroforestry has many potential, such as enhance the overall (biomass) productivity, soil fertility improvement, soil conservation, nutrient cycling, microclimate improvement, carbon sequestration and biodiversity conservation *etc*. Now a days agroforestry has gained popularity among farmers, researchers, policy makers and others for its ability to contribute significantly in meeting deficit of tree products; socio-economic and environmental benefits. Poplar is a very prominent taxonomical group of tree species in plantation forestry in India. Indigenous poplars occur only in the mountains and are still to acquire greater role and share in afforestation/reforestation programmes and conservation. However, its population in natural stands is small and is gradually declining. Bulks of the plantations are composed of *Populus deltoides* commonly known as poplar, an exotic Multi Purpose Tree species (MPTs) adopted in different agroforestry systems with a rotation period of 6-8 years, growth rate of 2-3 m^3/ha/yr (boundary plantation) to 20-25 m^3/ha/yr (block plantation) with a approximate return of Rs. 1.5 lakhs/ha/annum. Poplar is widely used for the manufacture of pulp, paper, plywood, snowboard core, bodies of electric guitars and drums, tanning leather *etc*.

Brief review of research work:

1-Agrisilviculture system

Mandal *et al.* (2012) reported that in a poplar based agroforestry system, there was net return of Rs. 8,70,350 (Rs. 7,89,500 from poplar and Rs. 80,850 from agricultural crops) from one acre of land in 5 year rotation.

Gandhi and Dhiman (2010) revealed that the mean value for grain yield, straw yield and harvest index of 56.5 q/ ha, 44.4 q/ ha and 0.56 respectively was significantly higher under 6x6 m spaced trees when compared with other spacings.

Mishra *et al.* (2004) found that yield attributes of soybean *viz*. test weight, grain and straw yield were significantly influenced by poplar clones in agrisilviculture system. Grain and straw yields were significantly higher in sole soybean and lower under poplar clones. Grain and straw yield reduced from 2.06 to 33.1 per cent and 16.81 to 47.84 per cent respectively under different clones and lowest reduction of these characters were under S7C1 clone.

Kareemulla (2013) reported that B:C ratio (3:1) and net return (Rs.28879/ year) were maximum in poplar based agrisilviculture system as compared to other agroforestry systems.

Dhillon *et al.* (2001) stated that Net Present Value (NPV) of poplar without intercropping and with intercropping were Rs. 111103 and Rs. 167563 respectively.

Chauhan *et al.* (2009) observed significant increase in poplar tree parameters like tree height, DBH, crown spread, volume from 1 to 4 years of age whereas wheat yield was gradually decrease from 25.29 to 13.08 q/ha with increasing the age of trees.

Chahal *et al.* (2012) revealed that the highest total net return and average net return/ha/annum of Rs. 3,86,128 and Rs. 64,355 respectively were obtained in poplar + sugarcane based system.

Rizvi *et al.* (2011) revealed that the timber volume production was maximum in agrisilviculture system of 132.99 and 118.48 m^3/ ha in Saharanpur and Yamunanagar respectively as compared to boundary plantation at the rotation period of 7 years.

Dhiman and Gandhi (2010) reported that maximum return of Rs. 58,895/ha was from the crop in open condition and decrease in net profit from Rs. 34605 to Rs. 13158 with the increase in age of poplar from 35.5 months to 83.5 months.

Garima and Pant (2017) stated that maximum grain yield and harvest index were recorded in T6 (25 % FYM+ 25 % VC and 50 % CF) and S3 (open condition) of 23.26 q/ha and 27.32 q/ha respectively however the interaction of spacing and fertilizer dose was no significant.

Chauhan *et al.* (2012) revealed that the wheat grain and straw yield in poplar plantation were decreasing from 17.03 to 52.15 per cent and 12.46 to 48.72 per cent respectively in comparison to control condition with the increase of age of poplar plantation.

Sarvade *et al.* (2014) concluded that significant higher wheat grain yield and harvest index were recorded in poplar, spacing of 3×2.5 m and 180-60-40 kg/ ha NPK fertility level of 25.6 qha^{-1} and 0.34, 27.3 $qha^{-1}$and 0.35, 38.4 qha^{-1} and 0.39 respectively.

Chaturvedi and Pandey (2001) found that maximum gross income and DCR (Deflated Cost Revenue): DCE (Deflated Cost Expenses) ratio of 38,492 US$ and 37,792 US$; 5.01 and 6.68 respectively from maize-wheat-turmeric crop rotation system and pigeon pea- turmeric crop rotation system practiced under 1-9 years old poplar plantation.

Chauhan *et al.* (2012) revealed that intercropping of agricultural crops with poplar generally enhances tree growth in general and biomass of 178.4 kg/tree as compared to poplar as pure plantation of 163.3 kg/tree.

Pal *et al.* (2009) showed significant difference in yield potential of wheat varieties under poplar. Maximum grain yield (29.35q/ha) and harvest index were found in wheat variety of WH 542 (43.71%).

2- Other Agroforestry systems

Dogra *et al.* (2014) concluded that the Mean Annual Increment (MAI) and NPV were found maximum in Site Quality(SQ)- I of 36.2 t/ha and Rs. 8.58 lakh/ha respectively as compared to SQ-II, SQ- III and NPV of wheat+ fodder crop of Rs. 2.49 lakh/ha.

Ranjan *et al.* (2016) reported significantly maximum fodder yield per hectare was recorded under T_0 (open field condition) while as intercropping maximum fodder yield (68.31t / ha) was recorded in treatment T_1C_1 (oat grown under subabul) followed by (51.55 t / ha) in T_2C_2 (lucerne grown under poplar).

Rathee *et al.* (2017a) found that net return and B:C ratio highest in fennel of Rs.118990 and 1.66 and ajwan of Rs. 94590 and 1.32 respectively under poplar based agroforestry system with 18x2x2 m spacing.

Rathee *et al.* (2017b) concluded that net return and B:C ratio highest in coriander of Rs.128090 and 1.78 and methi of Rs. 129690 and 1.79 respectively under poplar based agroforestry system with 18x2x2 m spacing.

Yadava (2009) reported the higher net return and net return per rupee invested were of Rs. 80629.8 and 5.47 in treatment S2F3(40x40 cm and 150:40:40 kg/ha NPK) and S2F2 (40x40 cm and 100:40:40 kg/ha NPK) as compared to other treatments.

Dutt and Thakur (2004) intercropped *Tagetes minuta*, *Spilentus acmella* and *Withania somnifera* under different spacings of poplar and found that among different spacings 8x3 m excelled over 6x4 m, 5x5 m and 4x6 m, which ensured significantly higher net returns from the combination. From economic prospective, medicinal aromatic crops can be arranged in descending order as *Spilentus acmella* (Rs. 254395.6) > *Tagetes minuta* (Rs. 51049.6) > *Withania somnifera* (Rs. 22264.6) at a spacing of 8x3 m.

Kumar and Madan (2016) reported that the highest BCR of 2.9 was recorded in giloe planted in 5×4m and shatawari (2.8) planted in 5×4m and 10× 2 m poplar spacing. Thus shatawari and giloe can be advantageously grown in closer spacings of poplar. However in kwanch the value of BCR was highest (2.8) in control condition and lowest (1.8) in close spacing, thus confirming that this crop is not suitable to grow in the shade of trees.

Chauhan *et al.* (2013) concluded that the income from moong crop followed by garlic/onion (spice crops) + fruit crops and poplar timber had maximum income (US$ 5725) followed by turmeric + fruits and poplar (US$ 4814).

Dhanda *et al.* (2007) revealed that the flowering crops such as *Dimorphtheca aurantiaca* (1.17 q/ha) and *Calendula officinalis* (3.46 q/ha) require partial shade for higher seed production and can be successfully grown under block plantation of poplar.

Conclusion:

Poplar a promising MPT adopted in different agroforestry systems particularly in the agrisilvicultural system is preferred and practiced by the farmers to enhance the economic return from the same piece of land. Review showed that poplar as a monoculture or in agroforestry systems generate more income in terms of net return than the agricultural crops. Poplar based agroforestry systems generate high return in terms of B:C ratio which varies in the range of 1.32 to 5.47. Poplar in agroforestry systems with wider spacing and rotation of 5-8 years are high in productive potential though the agricultural crops production decreases with the increase in age of poplar however the net return is high by adding the poplar production value. Productive potential of poplar based agroforestry systems is high in Indian condition due to availability of improved clones, standard planting and management technique, with judicious selection of crops. So from the foregoing discussion it may be concluded that poplar based agroforestry systems are highly productive in nature and success in Indian conditions particularly Northern part of India and further research trial should be carried out in other parts of country to get the benefit of poplar

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Seminar No. 71

Speaker : **Ms. Sukhadiya Madhuri L.**	Reg. No. 2030316006
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. N.S. Thakur**	Venue : Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 07/10/2017

TREES AS FEED AND FODDER RESOURCES: POTENTIAL AND PROSPECTS FOR SMALL RUMINANTS

Small ruminants play an important role in the food and nutritional security of millions of rural people especially the landless, marginal and small farmers. The socio-economic value of small ruminant rearing for poor and marginalized farmers is immense compared to other livestock species. They provide a variety of products like meat, milk, skin, wool and manure, and thrive well in the semi-arid and arid regions with sparse vegetation and extreme climatic conditions. The rural poor people who cannot afford to maintain a cow or a buffalo, substitute sheep and/or goat as best alternative source of supplementary income. It has peen realized that the potential opportunities to expand and drive benefits from integrating small ruminants into annual and perennial cropping systems remain largely unexplored (Sahoo, 2016). They are mainly maintained on natural vegetation, common grazing land, uncultivable land, waste land and top feeds. Leaves and pods of fodder trees or shrubs are known as "Top Feeds" which serve as fodder for small ruminants. These trees and shrubs provide nutrients to the livestock virtually free of cost during lean period when surface grass is grazed away and other type of fodder are not available (Meena *et al.,* 2012). Trees, shrubs and grasses contribute large amount of feed and fodder to the small ruminants: To make the small ruminant, rearing sole or integrated manner, productive and economical, it is important to explore the quality and extent of tree feed and fodder resources.

Brief review of research work:

Medrano (1991) reported that feed intake and live weight gain (LWG) of sheep increased with increasing levels of Gliricidia sepium leaves. Sheep fed with 80% Gliricidia + 10% rice straw + 10% Setaria splendida gave the highest adjusted LWG (49.70 g) which was significantly better than those receiving lower levels of Gliricidia and 20% concentrate. The lowest LWG (20.4 g) was obtained in sheep fed on concentrate + 70% rice straw + 10% Setaria. A ration containing 80% Gliricidia sepium resulted in highest efficiency.

Rangnekar (1991) reported that animal owners traditionally use tree leaves, bushes and creepers for feeding animals. Besides the leaves, they make extensive use of the flowers, pods and seeds of some trees as feed supplements. The use varies with season, depending on availability. They found highest crude protein (CP) 22.9 per cent in leaves of *Morinda tomentosa* and 20 to 22 per cent in leaves of *Alangium salvifoliurn.* They also found that many tree leaves, flowers and pods are useful in improving milk production, milk fat, body condition and induction of oestrus.

Leng *et al.* (1991) revealed that supplements of *Enterolobium cyclocarpum* leaves significantly increased the rate of body weight gain (24%) and wool growth (27%) due to improved efficiency of feed utilisation and therefore probably represent a change in the protein to energy ratio in the nutrients absorbed.

Smith (1991) recommended that as supplements, the optimum dietary level of fodder trees and shrubs should be about 30 to 50 per cent of the ration on dry matter basis, or 0.9-1.5 kg per 100 kg body weight.Reynolds and Cobbina (1992) found that supplementary browse resulted in increased rate of weight gain in growing and fattening sheep. Further they recorded that sheep and goats fed with *Leucaena leucocephala* and *G. sepium* foliage increased the overall productivity of dams as measured by weight of offspring weaned/dam/year.

Fadiyimu *et al.* (2016) observed that average growth rates of sheep fed containing 75% *Panicum maximum* + 25% Cassava leaves (12.74 g/day) were significantly higher than 100% *P. maximum* (control) and 75% *P. maximum* + 25% *G. sepium.* However, they were comparable with 75% *P. maximum* + 25% *Moringa oleifera* (11.31 g/day). Animals probably utilized the supplemented diets better than the control. Supplementation with either *M. oleifera* or *G. sepium* leaves is capable of sustaining a favorable health status in small ruminants. The results also show that female animals had better growth rates than the males under study (11.0 versus 8.4 g/day).

Ebrahim *et al.* (2017) reported that increasing level of mulberry leaves improved the grass hay dry matter (DM) intake, total DM and nutrient intake. They recorded highest total gain (7.0±0.71 kg) and average daily gain (ADG) (77.8±7.86 g/day) with dietary composition Hay *ad lib.* + 289 g DM/d/sheep (33% concentrate mix + 67% dried mulberry leaves) then other feeding treatments.

Srobana Sarkar *et al.* (2016) observed that the *in vitro* total dry matter digestibility (IVTDMD) am *in vitro* total organic matter digestibility (IVTOMD) increased in treatments T_1 (45% wheat straw + 45% cone: mix. + 10% *L. leucocephala* leaves, T2 (same as T1 along with additional 1% malic acid and T3 (T,+ additional 2% malic acid) than control. The increase in digestibility with supplementation of *L leucocephala* leaves might be due to fulfilment of nutritional adequacy required for fermentation. Addition of malic acid resulted in further increase in the IVTDMD and IVTOMD in treatments T2 and T3.

Narayan *et al.* (2013), in feeding studies of *Trema orientalis* (Jhunjhuna) leaves on male goats, recorded the ADG of 46.70 g/day as compared to control. The gain in body weight showed that the Jhunjhuna leaves supplied all nutrient required for maintenance and growth.

Kass *et al.* (1991) overviewed dry matter intake (DMI), IVDMD and ADG in their study and reported that dry matter intake (DMI) by goats fed on shrub and tree foliages was very high. However, *Gliricidia sepium* foliage was found to produce an erratic DMI. Further, they mentioned that supplementation of *Pennisetum purpureum* and green banana fruits with increasing amounts of *Erythrina poeppigiana, Morus* spp. and *Malvabiscus arborescens* foliages enhanced milk yields and daily gains ii goats and lambs, respectively.

Nyamukanza *et al.* (2008) observed that different goat breeds fed on *Acacia karroo* tended to have a higher ADG 104.8 ± 8.45 (g/day) as compared to the goats fed on pellets 40.5 ± 9.45 (g/day). The average daily gain of the two goat breeds did not differ significantly.

Chaudhary *et al.* (2006) found higher total digestible nutrients (TDN) content in the ration of sheep fed on drumsticks. Intake of crude protein (CP) and ether extract (EE) and the net digested CP and EE was higher in the drumsticks fed group. They reported an improvement in the voluntary feed intake, nutrient digestibility, body weight gain and feed conversion efficiency in goat when poor quality grass was supplemented with *M oleifera* leaves. The results indicated that drumstick leaves could be used as green fodder like berseem without affecting nutrient utilization in sheep.

Khanal and Upreti (2007) observed highest daily weight gain for goats fed on *Artocarpus lakoocha* (71 g/d) and *Garuga pinnata* (64 g/d) than either of *Bauhinia purpurea* (54 g/d) or *Ficus roxburghii* (30 g/d). Overall, leaves and twigs from these tree fodders supported the moderate growth. Further, they mentioned better growth rates of female goats fed with *A.s lakoocha* and *G. pinnata* than *B. purpurea* and *F. roxburghii.* Goats in *A, lakoocha* tended to grow faster than goats in *G. pinnata* even though the digestibility and intakes of nutrients in these two groups were similar.

Esnaola and Rios (1990) found that goats fed on basal diet of *Pennisetum purpureum* (King grass) and reject banana fruit responded with linear increases in milk production when offered increasing levels of foliage of *Erythrina poeppigiana.*

Conclusion:

Asia harbour the largest population of small ruminants; however, feed resources are insufficient. It is evident that the Asian-Pacific region is richly endowed with a diversity of fodder shrubs and tree species that can serve as useful feed and fodder resources. At present, most of the trees and shrubs used in farming systems comprise those that grow naturally in the forest and in uncropped marginal lands. Sufficient evidence from research has shown that improved animal production can be obtained by incorporating tree and shrub fodders as protein supplements. The available literature shows that trees feed and fodder provide protein rich resource during lean period like *Leucaena leucocephala, Gliricidia sepium, Albizia lebbeck* and *Morus alba* contain 20 to 24% CP. The studies show that the tree fodder either sole fed (like *Artocarpus lakoocha, Garuga pinnata)* or in combination with grasses/concentrates result in increased milk and meat production in small ruminants. The dietary composition involving tree leaves have been found to improve the milk quality in terms of fat content.. Further, the inclusion of tree fodder in ration of small ruminants increase the feed intake; digestibility and its efficiency. Thus, fodder trees/shrubs act as productive potential _ source for small ruminants.

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Seminar No. 72

Speaker : **Ms. Odedara Varsha H.**	Reg. No. 2030316003
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. D. Nayak**	**V**enue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 07/10/2017

AGROFORESTRY INTERVENTION FOR SOIL AND WATER CONSERVATION

Land degradation is a process in which the value of the biophysical environment is affected by a combination of human induced processes acting upon the land. It is the temporary or permanent lowering of the productive capacity of land and it, thus, covers the various forms of soil degradation, adverse human impacts on water resources, deforestation, and lowering of the productive capacity of rangelands. Water and wind are the primary agents that cause soil erosion induced degradation. Other causes of soil degradation include acidification, overgrazing and deforestation. In India total degraded land is about 147 M ha (Anon, 2004). Land degradation affects soil structure, soil properties, also loss of soil nutrient and productivity as well as long term socioeconomic impact on human life like migration. Many soil erosion control methods are adopted in general; moreover agroforestry is one of the most important biological methods of conservation soil and water. Forest survey of India, 2013 has reported that about 25 million ha area in India (8.2 % of the total reported geographical area) is under agroforestry in both irrigated and rainfed agriculture which also includes trees outside forests and scattered trees on and off the agricultural fields. Agroforestry systems are among the innovative options to manage and conserve soil and water in field restore soil fertility, halt desertification, increase nutrient and water use efficiency, increase soil organic matter and soil structural properties. For example alley cropping useful in controlling erosion from sloping lands. In steep sloping soils of Indonesia, alley cropping reduced soil erosion by 64%. Silvopastoral agroforestry is an ideal system for soil and water conservation where trees and pasture prevents water and wind erosion. silvopastoral system play a major role in soil erosion control, since the system has two predominant canopy levels intercept the raindrops and reduces runoff velocity (Blanco and Lal, 2010).

Brief review of research work:

1.Soil Conservation:

The soil erosion in sloppy lands without agroforestry practices may go upto 200 Mg ha^{-1} yr^{-1}, whereas with agroforestry practices, the erosion is reduced up to < 5 Mg ha^{-1} yr in 14 - 20% same sloppy land (Panningbatan *et al.* 1995).

Sharma *et al.* (2001) observed high soil loss and subsequent nutrient losses from open agricultural (cropped) field, which was more than 72 percent as compared to the forest and the large cardamom agroforestry system of mountain farming systems in Sikkim Himalaya.

Kinama *et al.* (2007) observed runoff from Short Rainfall (SR93/94) till Long Rainfall (LR95) in the sole crop treatment amounted to cumulative total of 98 mm of the total rainfall. The hedgerow + mulch treatment was most effective in controlling runoff (cumulative 20 mm) as compared to the mulch only (36 mm) or Grass (46 mm) treatments and it is observed that cumulative soil loss for Short Rainfall till Long Rainfall seasons was reduced from 106 t ha^{-1} in the control treatment to 2 t ha^{-1} in the hedgerow + mulch treatment. Grewal (1993) studied the soil loss under different land use systems in Shivaliks, and observed that soil loss was negligible (0.01 ton ha^{-1}) under Eucalyptus-Bhabar grass system and higher soil loss was found in cultivated fallow system (5.6 ton ha^{-1}).

Udawatta *et al* (2010) investigated about the annual runoff under agroforestry buffers, grass buffer and control. The runoff in agroforestry, grass buffer and control treatment was 2655, 3067 and 5598 m^{-3} ha^{-1} respectively between 2004 and 2008. There was 25 percent reduction in sediment loss by agroforestry buffer area as compared to the total treatment area.

Liu *et al* (2017) observed the effect of litter layer on controlling surface runoff and erosion under monoculture rubber and tea/rubber plantations. The soil erosion from plots with bare soils, plots with litter

layer, and plots with litter layer plus undergrowth was 4.73, 1.92 and 0.91 t ha^{-1}, respectively. Rubber/tea agroforestry with a thick, intact litter layer was more effective in runoff and erosion control than rubber monoculture.

Tomar *et al.* (1992) observed the decomposition of *Pueraria hirsuta, Broussanatia paprifera* and *Leucaena lecocephala* which was 90% or more after 5 months. The order of decomposition of mulch material was *P. hirsuta* > *B. paprifera* > *L. lecocephala* > *Eucalyptus hybrid* > *Shorea robusta.* After harvest of wheat as well as maize lower pH was observed under mulch treatments as compared to control. Lowest soil pH was recorded under *Eucalyptus hybrid* (pH reduce from 5.6 to 5). Slight improvement in respect of total nitrogen under *L. Leucocephala* and highest P content was recorded under *E. hybrid.*

Kaur *et al* (2002) studied tree species of *Acacia nilotica, Dalbergia sissoo* and *Prosopis juliflora* along with grass species of *Desmostachya bipinnata* and *Sporobolus marginatus.* Nitrogen mineralization rates were found greater in silvopastoral systems than grass system alone. The soil carbon content increased by 24 to 62% and the nitrogen content by 20 to 46% in the trees + grass systems as compared to the sole grass system; the maximum carbon and total nitrogen was found in *Prosopis + Desmostachya.* Soil pH reduced to 8.6 to 9.9 after six to seven years of trees growth in the silvopastoral systems.

Singh *et al* (2014) observed the significant effect of Agroforestry systems on ESP (Exchangeable sodium percent) which recorded up to 120 cm depth of soil. Under all silvopastoral systems, ESP significantly reduced under different depth of soil as compared to control barren land.

Narain *et al* (1997) studied sediment deposition along vegetative barriers at Dehradun. The low sediment deposited was found in *Leucaena* hedge with turmeric field (47.3 ton ha year-^{1}) as compared to other vegetative barrier. High soil loss was found in *Leucaena* hedge with maize field (12. 1 ton $ha^{-1}year^{-1}$) where as lowest soil loss was found in *Eucalyptus* trees with maize.

2.Moisture Conservation

Pollock *et al* (2009) monitored soil moisture content at 0 to 2 m depth under 2 - 6 years old Radiata pine with three under storeys of bare ground, *Lucerne* and ryegrass/clover. The maximum plant available moisture storage was 207 — 223 mm in the top layer soil. However, it was only 69 - 104 mm moisture storage at 1 -2 m depth where coarse textures often predominated. A group of scientists reported that without agroforestry practices higher soil bulk density was found in inceptisol soil order (1.48 Mg m^{-3}) and with agroforestry practices lower soil bulk density found in alfisol soil order (0.66 Mg m^{-3}) and higher water infiltration found in lixisol/alfisol(135 mm h') with agroforestry practices.

Bharati *et al.* (2002) observed that soil infiltration capacities are greater under the multispecies riparian buffer (MRB) than under cultivated fields and grazed pasture. The average 60 minute cumulative infiltration rates from MRB were 5 times greater than that from the cultivated fields in pastures.

Narain *et al* (1998) observed that the crop yield was drastically reduced in the vicinity of trees *(Eucalyptus* and *Leucaena).* Wheat biomass production progressively declined towards tree-rows compared to mid-alleys. Also, the moisture distribution across the alley at sowing and 90 days after sowing of wheat and grass were also followed a similar pattern. Wheat/grass biomass yield and soil water content were more or less uniformly distributed across the tree alleys.

3.Soil and Water Conservation

Aguiar *et al.* (2010) observed the amount of sediment losses and percentage of water loss runoff, in 2003. There were no substantial differences in sediment losses in 2004. NF1 Native forest 1 (NF1) and TRAG Traditional agrosilvopasture system (TRAG) showed the largest amount of sediment losses, reaching 1.4 and 0.7 Mg ha^{-1}, respectively. Water loss in both years were higher in TRAG (Traditional agrosilvopasture), IC (Intensive cropping) and NFl (Native forest 1) compared to the other cropping systems. AGP (agrosilvopasture) and SILV (silvopasture) systems recorded the lowest amounts of sediment and water losses, as compared to other cropping systems.

Mishra and Rai (2013) evaluated the indigenous soil and water conservation practices in watershed of Sikkim Himalaya. Though only mechanical measure showed higher soil and water conservation, but agroforestry practices as a biological conservation measures also showed more than 70% soil and water conservation. Further, traditional crop residue and weed burning is 100% better in soil fertility management for all ecological zones of the watershed.

Vanlaihauna *et al.* (2010) studied relative efficiency of different types of mulch materials such as rice straw, weeds and subabul leaves applied at 6,8 and 10 t/ha on rainfed turmeric agroforestry systems for soil moisture conservation where rice straw conserved more soil moisture than subabul leaves and weeds (10 t mulch/ha > 8 t mulch/ha >6 t mulch/ha), respectively.

Conclusion:

From the study, it is concluded that agroforestry land use fulfil both productive and service functions. The main productive outputs are food-grains, fuelwood and fodder whereas most important service function is soil and water conservation. Most of the report showed that Agroforestry systems reduce soil erosion, control runoff and improve the soil quality (both physical and chemical).

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Seminar No. 73

Speaker : **Ms. Patel Rinkuben A.**	Reg. No. 2030316004
Degree : M.Sc. Forestry (Forest Genetic Resources)	Course No: FOR-591
Major Adviser: **Dr. M. S. Sankanur**	Venue: Conference Hall
Minor Adviser: **Dr. S.K. Jha**	Date: 07/10/2017

STATUS OF TREE IMPROVEMENT STUDIES IN *Gmelina arborea* Roxb. Ex. Sm

The gap between demand and supply of wood and wood based products are widening year by year. While most of these demands are met either from natural forests or plantations, putting pressure to fill the gap from natural forest can be risky in a view of conservation of biodiversity, natural ecosystem and moderation of climate change effect. Moreover, increasing population, industrialization and urbanization across the country has made it imperative to increase the productivity of the existing plantations. Green revolution in crop has

already shown the potential of genetic improvement in increasing productivity. However improvement work is largely lacking in forest trees. *Gmelina arborea* Roxb. Ex Sm. is one of the potential fast growing multi-purpose indigenous tree species belongs to family Lamiaceae (Chudnoff, 1979). In world, it is spread in South East Asian countries and in India, it is spread throughout greater part except J & K, Himachal Pradesh & Sikkim (Kavitha *et al*., 2016). It has also been introduced to at least 35 countries, eight of which have planted it on a large scale (Adam & Krampah, 2004; Ganeshaiah & Kailash, 2016). Many tree planters considered *Gmelina* to be a very promising species due to ease and cheapness of establishment, rapid early growth, expectations of early returns and promising wood characteristics, including high durability and good yield and quality of pulp. Hence, the FAO (1969) Panel of Experts on Forest Genetic Resources assigned top priority for improved utilisation and conservation to *G. arborea*. To start with any improvement programme it is essential to know the existing status of improvement in the species. These reasons prompted to select the present topic for delivering the seminar.

Brief review of research works:

Solomon and Rao (2006) reported that *G. arborea* is a dry season bloomer. The breeding system involves both self- and cross-pollination. However, most of the fruits results from autogamy drops prematurely. The floral characteristics suggest it is pollinated especially by Xylocopa bees and passerine birds.

In CAMCORE trial, Hodge and Dvorak (2004) reported that, at all ages, single-site heritability estimates for height, DBH, and volume were moderately low, around h^2_b = 0.10. Strong age-age additive genetic correlations were found for all growth traits and all age combinations. There was relatively little G×E interaction at the provenance level (r_{Bg}=0.73), and relatively substantial G×E interaction at the family level (r_{Bg}= 0.40).

ICFRE (2001) established seed production areas two each in Assam (16 ha) and Madhya Pradesh (24 ha) and one in Karnataka (1.5 ha) to meet interim supply of improved *G. arborea* seeds. This esteemed institution also involved in establishment of seed orchard in different states *viz.*, Arunachal Pradesh (3 ha), Chhattisgarh (39 ha) and Tripura (5 ha). Further, they also established 2 provenance trails in Nagaland (2.5 ha) 1 in Tripur (1.7 ha), 32 in states of Uttar Pradesh, Punjab, Haryana (8.0 ha) and 13 in the Rajasthan, Gujarat, Deu & Daman (5.0 ha).

ICFRE (2003) established 2 provenance trials in Nagaland (2.5 ha), 1 in Tripur (1.7 ha), 32 in states of Uttar Pradesh, Punjab, Haryana (8.0 ha) and 13 in the Rajasthan, Gujarat, Deu & Daman (5.0 ha).

Soosai *et al.* (2017) examined 15 half-sib families of *G. arborea* for their growth attributes and genetic divergence at the IFGTB field research station situated in Kuruvampatti, Salem. Among these, three families KEKBG, TCBSG-2 and KEAVG exhibited consistent superiority during the growth period for tree height, GBH and volume index. Cluster analysis grouped the 15 half sib families into seven clusters. The volume index trait contributed for maximum genetic divergence followed by tree height and GBH. Similarly the PCV and GCV estimates exhibit superior values for the volume index followed by tree height and GBH. The present genetic analysis study indicated the presence of adequate variability among the 15 half sib families.

Indira (2006) carried out provenance trials of *G. arborea*. Growth performance, tree form and the characters controlling them were studied. With respect to tree form, the provenances varied significantly for clear bole percentage and tapering. Axis persistence, straightness and mode of branching also had significant variation between provenances at one of the sites. The provenance, Khasi Hills, showed the best performance at both sites for tree form as well as growth in the early years.

ICFRE (2011) conducted progeny trial of *G. arborea* established at Gudalur Research Station and Neyveli Research station using 41 CPTs selected from Tamil Nadu, Andhra Pradesh. Data related to seed parameters, seed weight, germination percentage, growth parameters of seedlings up to 4 months during the juvenile phase showed wide variation. Further in one more study the clones ranked based on their height, stem straightness, dbh, pruning ability and crown form. On the basis of initial screening for the pest resistance to defoliator, eight clones found moderately resistant in the field to the defoliator. In any another study conducted on genetic improvement of *G. arborea* through selection and clonal evaluation. They selected 50 CPTs based on growth superiority, clear bole, pest and disease resistance.

Wee *et al.* (2011) analyzed 534 samples representing a total of 19 natural populations across different countries *viz*., India (7), China (3), Thailand (2) and Myanmar (7) using 10 polymorphic microsatellite markers. Where they reported that, genetic diversity analysis showed a highly polymorphic loci (Na = 16.4), further, a good level of genetic diversity (Ho = 0.56; He = 0.83) and the deficiency of heterozygotes in *G. arborea* populations (except Indian population) evidenced positive fixation index and deviation from Hardy–Weinberg Equilibrium in all loci and most of populations. Analysis of molecular variance attributed 21, 10 and 69% of total genetic diversity in among-region, among-population within region and within-population variation, respectively. Nei's Unbiased Genetic Identity showed that at the population level, genetic identity between the populations ranged from 0.07 (Chessa-Ladagyi) to 1.00 (Amboli-Kasa, Amboli-Nowgong and Kyun Taw-Waibon).

Kumar (2005) conducted a clonal trial of *G. arborea* consisting of 70 clones which were evaluated for height, diameter at ground level (DGL) and diameter at breast height (DBH) at the Experimental Station, RFRI, Jorhat, Assam. The performance of all the traits at the age of 24 months showed significant variations between the clones. Clone 106 maintained 1st rank over the period. Clones 9, 17 and 79 showed a upward trend whereas clones 3, 7, 11, 16, 27, 39 and 101 showed a decreasing trend. The interim assessment of different clones indicated large genetic improvement possibilities in *G. arborea.*

Lokmal (1994) examined an open-pollinated progeny trial from 36 plus trees of *G. arborea*. Heritability values for Height ranged from 0.068 to 0.178 while for DBH, it was about to 0.12. The values for both traits were very low indicating a very low degree of inheritance. Phenotypic ($T_{P)}$ and Genotypic (Tg) between Height and DBH at year one to six were strong (> 0.5), indicating that early selection for these traits would be effective. It is suggested that low intensity mass selection followed by high intensity family selection could be carried out to warrant good response in ΔG.

Naik *et al*. (2009) studied genetic diversity in *G. arborea* in *in-vitro* responses of cultured nodal segments from plants of eight different populations representing natural forests, fragmented forests and plantations. Genetic diversity was analysed using molecular marker (ISSR) yielded 95% polymorphic loci among the eight populations and UPGMA analysis enabled separation of these populations on the basis of their genetic distances. Nei's genetic diversity was 0.29 between populations and 0.11 within populations. AMOVA analysis indicated 41 and 59% within- and between-population genetic diversity, respectively. Assessment of the genetic variation in *G. arborea* populations is an important step in selection of conservation strategies for this species since diversity forms the basis for species adaptation.

Conclusion:

Most of the studies confirms larger amount of inter and intra population variability in *G. arborea*. This may be attributed to its cross pollination nature. Overall, the intra-population variability is higher in the species. Higher age-age correlation for growth and volume characters can be effectively utilized for early selection for growth and volume traits. Despite large distribution area, only a limited number of provenance and progeny trials have been conducted so far. The number of seed orchard and seed production area is also limited in number. Most of the studies were confined to smaller number of population/genotype which may sometime show faulty or biased picture about existing variability

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Seminar No. 74

Speaker : **Ms. Rashmiprava Maharana**	Reg. No. 2030316005
Degree : M.Sc. Forestry (Agroforestry)	Course No: FOR-591
Major Adviser: **Dr. Manmohan J Dobriyal**	Venue: Conference Hall
Minor Adviser: **Dr. L.K. Behera**	Date: 08/11/2017

AGROFORESTRY SYSTEMS IN COASTAL AND ISLAND REGIONS

Coastal areas are commonly transition areas between land and sea, including large inland lakes. The total length of global coast is 3,56,000 km with Canada having the longest coastline length of 2,02,080 km. India has a coastline of 7516.6 km stretched over 32 Mha area covering 12 states and Union Territories. The mainland coastline length is 5422.6 km whereas Island territories coastline length is 2094 km. Gujarat has the longest mainland coastline in India *i.e.*, 1214.7 km which is approximately 23% of the country's total mainland coastline and Goa having the smallest coastline with 101 km (India, 2013). These areas are saline in nature due to periodic intrusion of tidal sea water where the mangrove and littoral species predominates. The total mangrove of whole coast is 4740 km^2 (57% East coast, 23% west coast, 20% Andaman &Nicobar Islands) The Sundarbans is the world's largest area of mangrove forest, spanning approximately 1 mha (2.47 million acres) in India and Bangladesh. (FSI, 2015). The coastal areas are dominant of loamy, deltaic and alluvial soils which vary with different agroclimatic zones. The prevalent agroforestry systems in these regions are home gardens, plantation based multi-storied cropping systems, multipurpose trees and shrubs on farmlands, live fence and hedges, shelterbelts and shore protection, silvopastoral system (fodder farming), aqua-agroforestry, brackish water aquaculture (aquaculture with mangroves) and afforestation for coastal saline areas.

Brief Review of Study

Dagar (1996) summarised the prevalent agroforestry systems of coastal and island regions in the 5 agroclimatic zone of India and found a total of seven types of agroforestry systems such as multi storied cropping systems, home gardens, farming in forests, multipurpose trees and shrubs on farmlands, alley cropping and system for coastal saline regions.

Dagar (1995) studied the existing and potential agroforestry systems in the Andaman and Nicobar Islands and found 4 principal systems (home gardens, plantation based multi-storied cropping system, forest farming and aquasilviculture). He also suggested how to secure improved productivity and wider adoption of the systems to make better use of degraded lands.

Kanak Lata *et al.* (2002) surveyed 19 homegardens of South Andaman to evaluate structure and composition of different components and their interactive relations and revealed 5 components (plantation trees, annual crops, poultry, livestock and fish pond) arranged in different strata. Total yield of the system was found 8.670 ton/ha and *Ceiba pentandra* contributed maximum (0.58 ton/ha) though having less density. Moreover, *C. pentandra* exhibit highest output/ input ratio (22.2) whereas minimum in bay leaf (1.32). Further, in the

subsidiary activity in the homegarden, poultry showed maximum (16.67) output/ input ratio as compared to livestock and aquaculture.

Pandey *et al.*(2005) evaluated the floristic composition, diversity and economic structure of five types of traditional homestead farming systems in the Andaman and Nicobar islands and found Coconut-Arecanut-Rice type has the highest diversity (3.48) and species richness (9.64) whereas net output/ input ratio was highest in Coconut- Gliricidia- Vanilla based system (10.22).

Rageena *et al.* (2007) surveyed the land use systems and found six types of system in the tropical homesteads of Kerala and revealed that efficiency, Benefit: Cost (BC) ratio and Monetary Equivalent Ratio (MER) were found maximum of 4525, 1.94 and 5.52 respectively in the model V (crop+ poultry +livestock + floriculture + ornamental fish culture + cardamom nursery + vermicompost unit).

Thampan (1996) analyzed the effect of intercrops on yield of coconut in a 50 year old plantation and concluded that yield of coconut significantly increased from 60 to 67 nuts/palm with the incorporation of cocoa.

Bhol *et al.* (2015) investigated the composition, structure and role of coconut (*Cocos nucifera* L.) based farming systems in different land holding sizes in the Puri district of Odisha and found very diverse composition consisting of perennial trees, annual crops and seasonal crops. The net return increased with increase in land holding size and highest BC ratio (2.13) was found having land holding size of 1.5 acres.

Kumar *et al.* (1998) studied the biomass accumulation of 9 multi purpose tree species in a farmland and found highest aboveground biomass and Mean Annual Increment (MAI) of 326.43 tonnes/ha and 37.09 tonnes/ha/year respectively in *Acacia auriculiformis.*

Pandey (2011) conducted an experiment to know the production potential and economic benefit of modified alley cropping system of agroforestry in South Andaman with the introduction of black pepper in the double hedge rows of *Gliricidia sepium* whereas maize and okra in the alleys. The results revealed that the net return from the modified system (*Gliricidia*+ okra+ maize+ black pepper) increased by 4.46 times than the traditional system (without black pepper).

Padmavathy and Poyamolli (2013) elucidated the relationships between biodiversity and income generation from agroforestry systems for livelihood security in Puducherry and concluded that relative frequency (20.4 %), abundance (45) and proportion (16.5 %) were found maximum in coconut based system whereas maximum BC ratio (10) was exhibited by parotia based system.

Bhusara *et al.* (2016a) analysed the biological yield of different agroforestry systems in the coastal district of south Gujarat and revealed that Teak+rice based agrisilviculture system produced maximum biological yield (53.12 t/ha) whereas among woody components teak in teak+rice based system and among intercrops banana in teak+banana based system accumulated maximum biological yield of 50.59 t/ha and 29.73t/ha, respectively.

Bhusara *et al.* (2016b) studied the bio-economic appraisal of prevalent agroforestry systems in the coastal district of south Gujarat and recorded maximum economic yield of intercrop in sugarcane (55.36 t/ha) under teak+ sugarcane system.

Dagar *et al.* (2014) reported about tree species found in the live fencing system in different coastal areas of India. Total 18 number of tree species and 15 number of shrub species were adopted in this system in the coastal areas.

Kumar *et al.* (2005) studied the ground biomass production and nutrient uptake of 20 years old thorny bamboo(*Bambusa bamboos*) and found highest biomass accumulation (82%) in live culms followed by thorns + foliage (13%) and dead culms (5%). They also reported the average litter accumulation (9.1t/ha) on the forest floor accounting for Nitrogen (482 kg/ha), Phosphorus (367 kg/ha), and potassium (430 kg/ha).

Sharma *et al.* (1992) found maximum oven dry biomass production in *Panicum maximum* grass (34 tons/ha/yr) and *Stylosanthes guianensis* legume (23.4 tons/ha/yr) when inter-cultivated with *Morinda citridifolia*.

Tandel *et al.* (2016) conducted an experiment on rice based aqua-forestry systems in Dandi of Navsari district of South Gujarat and found subsequent increase in net returns from the integration of tree species along with fish culture in the rice fields.

Nongmaithem *et al.* (2017) conducted a survey to document the prevailing agroforestry systems in Navsari district of south Gujarat and recorded five prominent types of agroforestry systems (Agri-silvi-horticulture, Agri-silviculture, Agri-horticulture, Homegardens and Horti-pasture) which showed that the

selection of intercrops depends on edapho-climatic conditions of the area, farmer's preferences, resource availability and their utilization pattern to enhance diversification and achieve resilience in the existing farmland.

Mohanty *et al.* (2010) analysed the productivity and economics of a Coconut based Integrated Farming System(IFS) and reported increase in net productivity (16.2t/ha/yr) along with the increase in gross returns(Rs 2,63,607/ha) and net returns and (Rs 1,46,767 /ha) from the whole system.

Conclusion

Agroforestry land use system has great relevance to the coastal and island ecologies particularly in the scenario of livelihood security and climate change. Reviews in the presentation confirm that different prominent agroforestry systems such as homegardens, integrated farming systems, pasture under plantation crops, rice-based aquaculture *etc*. are traditional systems whereas silvo-pastoral systems and coconut based agroforestry systems etc. are modified agroforestry systems adopted for their sustainability, profitability and adaptability. These systems are contributing towards livelihood security of marginal and small farmers of coastal and island ecologies. Further, most of the coastal areas are having saline soil which can be reclaimed by leguminous and salt tolerant perennial species, bio-drainage species along with coastal afforestation like shelterbelts and windbreaks to protect the agricultural lands. More research efforts are needed in domestication of valuable multipurpose tree species, value addition, carbon sequestration, coastal and island ecosystem management and popularization of these systems at country level.

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Seminar No. 75

Speaker : **Mr. Prajapati Dhavalkumar Rajeshbhai** Reg. No. 1030316001
Degree : Ph.D Forestry (Agroforestry) Course No: FOR-691
Major Adviser: **Dr. N.S. Thakur** Venue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga** Date: 08/11/2017

TREE-C_4/LEGUME BASED AGROFORESTRY SYSTEMS: POTENTIAL AND PROSPECTS FOR FODDER

Livestock population in the world is increasing day by day. Simultaneously, the demand of fodder is also increasing. The total livestock population in the country is 512.05 million numbers in 2012. The total livestock population has decreased by about 3.33% over the previous census (Anon., 2012). Land allocation to cultivation of fodder crops is limited and has hardly ever exceeded 5 per cent of the gross cropped area (GoI, 2009) hence low fodder availability. By 2020, India would require a total 526 million tonnes (Mt) of dry fodder, 855 Mt of green fodder, and 56 Mt of concentrate (Dikshita and Birthal, 2010).Whatever green and dry fodder fed to the livestock comes from cultivated and natural pasture (both trees and grasses). In most parts of world, especially in hilly and arid regions, after rainy season availability of fodder become scarce and animals suffer badly. In such conditions trees leaf fodder serve as top feed rich in proteins. To meet the year round requirement of green and dry fodder land use systems need to be developed. Here, agroforestry seems to be viable option. Agroforestry systems *viz*., silvi-pasture, agri-silvi-pasture, horti-pasture, Homegarden, silvi-horti-pasture, *etc*. encompasses the grasses, C_4 crops or legumes along with fodder/fruit/timber tree species. The tree based pasture systems can be used at different degraded lands which are less productive. Trees have high adaptability to a various harsh climatic conditions and can protect the animals from climate extremes along with producing pasture under its beneath which will support the livestock population. During rainy season the animals prefer to graze green grass, but as dry season arrives when there is no blade of grass available, they can be foliage of the trees and shrubs. Fodder and fodder production from these systems can be increased with better management like practicing silvicultural and better agro-techniques. Hence, it is suggested to develop fodder/fruit tree-grass/leugume systems to provide nutritious green forage and foliage (Pathak and Roy 1994).

Brief review of research work:

Bisht *et al*. (2014) estimated the forage (green fodder) yield (t/ha) of three grasses under *Dalbergia sissoo* based silvipastoral system on sodic land in Indo-Gangetic plains, Faizabad and found a clear cut increase in herbage yield of all three grasses along increasing lopping intensities.

Premi *et* al. (2001) studied the effect of different crop combination on production potential and quality and carrying capacity of improved grassland *vis-a-vis* silvipastoral system was.

Varsha (2015) examined the dry fodder yield of tree-grass systems over 2 year period from different fodder production systems at Vellanikkara, Kerala, India and concluded that 2-tier HN + mulberry system with tree density of 11,111 trees ha^{-1} was found to be the most promising system for meeting both farmer needs and environmental services.

Neel and Belesky (2015) evaluated grazing season herbage dry-matter yield (kg ha^{-1}) by grazing systems under 100% open pasture (OP), OP + silvopasture (OS), OP + silvopasture-delayed graze (OSD) and 100% silvopasture (SP) and suggested that development of silvopasture from existing woodlots has potential to improve whole farm productivity on marginal lands of Appalachia region of USA by increasing quality fodder production.

Neel *et al.* (2008) reported that 80% solar radiation resulted in better dry matter production and nutritional quality in mixture of sown grasses and legumes established under a mature stand of conifers over the period of 3 years, compared to lesser radiation levels.

Rusch *et al*. (2014) evaluated the effect of tree canopy or open grass land and season on grassland productivity in seasonally dry silvopastures of Nicaragua and reason out that trees had a predominately negative

effect on grassland productivity but can provide fodder (leaves, fruits) in the dry season when grassland productivity stops.

Thakur *et al*. (2015) evaluated total fodder production under different tree-legume-grass based agroforestry systems and suggested that to ensure year round supply of quality fodder these tree-crop combinations like *Grewia optiva + Setaria sphacelata + Mucuna pruriens* or *Morus alba + S. sphacelata + M. pruriens etc*. can be adopted in low hills of western Himalayas.

Anon. (1994) reported higher production of mixture karnal grass and sporobolus grass under the *Acacia nilotica* based than other tree based agroforestry systems and open pasture.

Mathew *et al*. (1992) studied the compatibility of different components in a silvo-pastoral system and revealed that *Casuarina equisetifolia* and *Ailanthus malabarica* recorded comparatively higher forage yield even after canopy formation.

Lehriya (2004) studied the productivity of grass under four different tree based pasture system and concluded that *Morus alba* based silvopasture system has accumulated highest dry fodder biomass followed by *Leucaena leucocephala.*

Sharma (2004) developed the hortipastoral system involving buffel and stylo grass to optimize the productivity and found that the mixture of buffel and stylo grass provided highest dry matter t ha^{-1} under the jujube tree than the treatments of open pasture and single species under the tree of the study.

Sharma (2004) evaluated pasture production (DM t ha^{-1}) of Sehima dominated natural pasture under various treatment combinations and reported that mixture of Sehima and Stylo produced higher biomass under the hortipastoral system at the IGFRI, Jhansi.

Chauhan *et al*. (2014) studied the effect on the productivity of fodder crop in the Leucaena (Subabul) alleys and found that the above ground biomass of the system was more compared to sole fodder production of annual (maize + cowpea followed by berseem + ryegrass) and perennial Napier Bajra hybrid.

Bhatt *et al*. (2006) estimated the dry matter yield and nutritional quality of *Cenchrus ciliaris* and *Panicum maximum* in open and under the canopies of *Acacia tortillis* and *L. leucocephala* based silvopasture system for the 7 year period and observed that *C. ciliaris* and *P. maximum* produced 4.20 t/ha and 6.84 t/ha dry matter under the canopies of trees but the *Panicum maximum* has shown high adaptability to maintain carbohydrate and crude protein level which indicate the optimization of fodder quality.

Kumar and Chaubey (2008) reported higher production in pasture involving trees as compared to pure pasture and suggested that the higher dose of nitrogen should be applied for the higher production of *Dichanthium* under Aonla based hortipasoral system.

Mynavathi *et al*. (2017) studied the suitability of *Calopogonium mucunoides* under *Cocus nucifera* / *Psidium guajava* based hortipasture system and found that higher biomass yield was recorded with the understorey of *C. nucifera* compared to sole crop and under *P. guajava.*

Reddy (2004) evaluated the production of fodder on the bunds of the farm at Central Institute of Dryland Agriculture, Hydrabad, and found that the mixture of napier grass and stylo grass gave the best results in terms of dry fodder yield under the various fruit tree based hortipastoral system.

Kumar *et al.* (2013) studied the effect of aonla trees on the pasture production of pearl millet and cow pea and recorded higher Green fodder production (t/ha), Dry matter production (t/ha) and Crude protein (kg/ha) in the T_3: Aonla + Pearl millet multicut based hortipastoral system.

Blair *et al.* (1990) evaluated the potential of legume tree-grass mixture for nitrogen yields (kg/ha) over a 4-month period and recorded that tree-grass mixture and trees monoculture produced similar nitrogen yield which suggests that trees-grass mixture produce highly nutritious fodder than monoculture grass.

Conclusion:

Many studies revealed that tree-C4/legume based agroforestry systems have significant effect on the forage production and forage quality. Tree-C4/legume based agroforestry systems has a potential to produce quality fodder through enhancing nutritive quality in degraded waste land where commercial crop cultivation does not take place. High yielding superior trees and grass/legume varieties can be applied to common grazing lands where fodder species composition is of inferior quality. This system has great potential in arid and semi arid

region where the forage availability is the main issue due to rainfed condition. As such system lowers the effect of drought, the system people should practice can be ber and aonla based hortipasture systems including *Dicanthium*, pearl millet, *stylosanthus* as forage crop which will enhance both forage production and income from the land. Integration of trees like *Grewia optiva* and *Morus alba* with forage crop like *Seteria, Pennicsetum purpureum* in traditional farming systems in hilly regions can heighten the fodder production with other benefits. Trees planting like *Leucaena leucocephala Dalbergia sissoo, Acacia nilotica* with forage species like *stylosanthus*, hybrid napier, berseem, cowpea in the humid tropics can fulfill the demand of fodder.

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Seminar No. 76

Speaker : **Mr. Ravindra Kumar Dhaka**	Reg. No. 1030316002
Degree : Ph.D Forestry (Forest Genetic Resources)	Course No: FOR-691
Major Adviser: **Dr. R.P. Gunaga**	Venue: Conference Hall
Minor Adviser: **Dr. Manmohan J Dobriyal**	Date: 08/11/2017

POLLEN HANDLING AND MANAGEMENT IN FOREST TREE SPECIES

Pollen handling and management in forest tree species is most sophistic management system in the world. Pollen grains play a vital role in the reproductive process of flowering plants. Pollen biology is of most significance in tree improvement programme as they decide the gene flow and heterozygosity of populations which in turn decides the genetic variability within and among forest population. Pollen management is the manipulation of pollen sources for a seed orchard or other breeding programme to accomplish dilution, isolation and application of pollen in order to increase the quantity and genetic quality of the seed crop. Insufficient quantities of pollen for full seed-set are frequently caused by lack of pollen production in the orchard; in fact, non-synchronous flowering cause for low fruit set in seed orchards. Pollen collection is mainly depends upon time of anthesis; moreover, behaviour of anthesis varies between species and sometime within a species and also depends on many factors such as pollinator visitation, temperature, relative humidity and stigma receptivity. Longevity of pollen varies greatly with tree species and storage conditions. Since most of the tropical species produce very sticky pollen, both collections as well storing is extremely difficult. Thus, the storage and handling procedures applied to collected pollen can modify pollen viability. In general for woody species, normal seed formation occurs when using pollen with at least 40 per cent germinability/viability. In forest tree breeding program, pollen can be applied to trees in micro and macro quantities as pure pollen or mixed with inert diluents like talc powder, dead pollen or pollen from related species. The many aspects of pollination practice in tree breeding and improvement, especially with reference to pollen handling, have been well used for controlled pollination in hybridization, supplement mass pollination, pollen culture and pollen conservation. Salient features of these aspects have been described through following case studies.

Brief review of research works

Pollen handling techniques

Khanduri and Sharma (2002) studied the microsporangium dehiscence and pollen production in *Cedrus deodara* at two different sites during 1998 and 1999. The data revealed that, in natural conditions, micro-sporangium dehiscence occurred between 08.00 and 18.00 h at both sites. However, a strobilus took 2-3 days to dehisce completely at the warmer location (Khirsu) and 3 day at the cooler location (Teka) due to variation in prevalent air temperature and relative humidity. Maximum dehiscence (6.6 % at the warmer site and 6.1 % at the cooler site, respectively) was recorded between 12.00 and 14.00 h, which was the peak period of microsporangium dehiscence in both the cases. Similarly, the production of pollen grains per microsporophyll, per strobilus, per branch and per tree in both the years was highly variable.

Kopp *et al.* (2002) studied the seven solvents *i.e.* acetonitrile, carbon tetrachloride, chloroform, dichloromethane, ethyl acetate, ethyl ether and toluene with control for pollen extraction in *Salix miyabeana* (clone Sx64) and *S. eriocephala* (clone S646). Per cent germination of pollen extracted was more in control; however, among solvent, toluene and carbon tetrachloride recorded maximum pollen germination than others.

Girijashankar (2010) compared the efficiency between wet-lyophylisation (WL) and conventionally dry-sieving (DS) methods of pollen isolation for wide-interspecific hybridization between 4 important species of eucalyptus in terms of per cent capsule set and seed set/10 capsules. The number of seeds obtained per capsule following DS method was in the range of 20-30 seeds, whereas in WL method, it was 30 to 40 seeds per 10 capsules. WL method of pollen isolation significantly enhanced the capsule set over the conventional DS method.

Horsley *et al.* (2007) studied the effect of storage temperature on *in vitro* pollen germination in three eucalyptus species, *Eucalyptus smithii, E. nitens* and *E. grandis* for a period of one year. By 12 months, cryostored pollen from two species (*E. nitens, E. smithii*) appeared to germinate better than pollen stored at any of the other temperatures. On the other hand, germination declined as storage temperature increased, with virtually no germination of room-stored pollen by 8 months.

Egenti (1978) found the maximum mean pollen tube growth (3.66 µm) in vacuum desiccator storage in teak as compared to storage (35 days), cooled incubator and deep freeze storage.

Thangaraja and Ganesan (2008) studied the effect of different storage conditions on the viability of pollen grains of *Terminalia paniculata*. The pollen grains stored in Benzene lost its viability rapidly and it came down to 15 per cent after 10 h of storage; however, the complete loss of viability under room temperature was at 26 h after storage. The viability was prolonged to 44 hrs of storage under cryopreservation.

Choudhary (2011) revealed that mean pollen viability percentage was higher for pollen stored at 4°C as compared to pollen stored at -20°C after 3, 6 and 9 months storage among different species/clones of *Salix*. Further, the long term storage showed a declining trend in the viability percentage at 4°C and -20°C storage temperatures.

Sankanur (2013) found that mean pollen viability percentage was higher for pollen stored at -20°C as compared to pollen stored at 4°C after 3, 6 and 9 months storage among various genotypes of *Terminalia chebula* with a declining trend in both storage temperatures.

Viability percentage of fresh pollen and killed pollen after 2 hours (2 h) and 24 hours (24 h) as determined by four vital dyes and *in vitro* germination was studied in *Calycotome villosa* by Rodriguez-Riano and Dafni (2000). Dyes in the first group (Baker's and X-Gal) always stained the killed pollen, although sometimes only the 2 h pollen; only the Baker's stained killed pollen faster than fresh pollen and X-Gal stained killed pollen at the same rate as fresh pollen. The second group (2,5-diphenyl monotetrazolium bromide- MTT) showed many different colour tonalities and sometimes the very dark pink pollen was difficult to distinguish from the black. In addition, MTT seldom stained the killed pollen, although when it did the stain was always lighter than with fresh pollen. Use of p-phenylenediamine was the most reliable method to distinguish between fresh and killed pollen, since killed pollen almost always turned greyish-brown, which strongly contrasted with the colour of fresh pollen; more importantly, it never stained aborted pollen.

Sedgley and Harbard (1993) studied four different staining dyes for polyads viability in *Acacia iteaphylla* and *A. karroo*. All methods gave variable results, however, staining with TTC and X-Gal gave unacceptably high variability for *A. karroo* and both stained more than a third of the killed polyads as positive. The most consistent results were obtained with the FDA stain, with killed polyads showing null per cent staining for *A. iteaphylla* and 12 per cent for *A. karroo* and a sharp decline in the number of stained polyads with increasing storage time. Interestingly, staining of fresh polyads varied from 37 in *A. karroo* with TTC to 98 per cent in *A. iteaphylla* with X-Gal.

A study conducted by Abdelgadir *et al.* (2012) showed that the Tetrazolium salt (TTC) stained fresh pollen bright red and it helped to distinguish fresh and dead pollens. Staining with 2,5-diphenyl monotetrazolium bromide (MTT), analine blue–lactophenol and IKI did not distinguish both fresh and dead pollen. In the fluorochromatic test, both fresh and dead pollen showed fluorescence and the variation between individual grains was too great to allow fresh and dead pollen to be distinguished reliably.

Brewbaker and Kwack (1963) standardized pollen germination media in 86 flowering plants including 79 genera representing 39 families with 10% of sucrose, 100 mg/l of boric acid, 300 mg/l of calcium nitrate, 200 mg/l of magnesium sulphate and 100 mg/l of potassium nitrate. It is most acceptable media and also called as BKM, BBM, BK or BM.

Wheeler and McComb (2006) compared BK and BA (Boric Acid) media for pollen germination in different clones and trees of *Eucalyptus marginata*. The pollen germination percentage was found higher in BK media as compared to BA media in all trees/clones except 503JP16 clone. More pollen grains germinated in the BK medium were containing Ca^{2+} ions than in the medium containing only maltose and boron.

Egenti (1978) standardized pollen germination media for teak. The medium containing 14 % sucrose resulted in 100 per cent germination on the day of anthesis and some pollen was still viable on three days after and one day before anthesis.

Sankanur (2013) studied effect of different sucrose concentration along with BK media on the pollen germination in *Terminalia chebula* and BK media containing 30 % sucrose resulted in higher pollen germination (86.06 %) than other concentration of sucrose.

Bhattacharya and Mandal (2004) studied *in vitro* pollen germination in *Moringa oleifera* and showed that 82 per cent pollen germination occurred in media with 10% sucrose. The best pollen germination (94%) occurred after 6 hrs incubation in 10% sucrose supplemented with 200 mg/ml boric acid solution. Other treatments showed poor pollen germination; in fact, potassium nitrate did not show any effect on pollen germination.

Thangaraja and Ganesan (2008) standardized pollen germination media for *Terminalia paniculata.* Maximum pollen germination (90.10%) and pollen tube length (62.40 µm) was recorded in BK media with 30% sucrose than others.

Bhattacharya and Mandal (2000) studied on pollen viability in *Bombax ceiba* through *in vitro* pollen germination using different organic and inorganic nutrients like sucrose, H_3BO_3, $Ca(NO_3)_2.4H_2O$, KNO_3 and $MgSO_4.7H_2O$. Among studied treatments, maximum pollen germination (97%) along with highest tube length (2940 µm) was recorded in 20% sucrose supplemented with 500 µg/ml H_3BO_3 solution. Among different salts of B, Ca, K and Mg; only B and Ca exert an effect on *in vitro* pollen germination.

David *et al.* (2012) observed percentage of germination of freshly collected pollen grains in BK medium with various concentrations of sucrose and also in sucrose solutions used alone (5 – 27.5) in *Terminalia arjuna*. No germination was noticed both in 2 % and 35% in sucrose either used alone or in combination with BBM. However, maximum germination was noticed after 8–10 hrs of inoculation in BBM containing 12.5% sucrose.

Dey *et al.* (2016) studied on *in vitro* pollen germination using different nutrient media at different time intervals after anthesis in *Mitragyna parvifolia.* The maximum pollen germination (96%) along with highest pollen tube length (1105 µm) was found after 3 hours in 10% sucrose solution supplemented with 100 ppm boric acid.

Thangaraja and Ganesan (2008) studied the *in vivo* testing of pollen grains viability in *Terminalia paniculata* based on the fruit set. The percentage fruit set was found to decrease towards the collection time of the pollen grains after the anthesis that dusted on the stigma. The pollen grains collected after 15 h of anthesis lost their viability and hence, there was no fruit set. Fresh collected pollen grains showed maximum fruit set (82 %).

Bhattacharya and Mandal (2000) studied on pollen viability in *Bombax ceiba* through *in vivo* pollen germination test. Stigmas were more receptive, *i.e.* 70% on the first day after anthesis and it showed 61 per cent *in vivo* pollen germination along with 317 µm long pollen tubes on the stigmatic surface. However, the receptivity percentage and *in vivo* germination pollen percentage was decreased in successive days after anthesis.

Pollen management

The intensive hybridization programme was initiated by Parthiban *et al.* (2009) through inter- and intra-specific hybridization using identified *Jatropha curcus* clones with related *Jatropha* species. Self and cross-pollination was made and the growth of pollen tube at different stages were recorded using a fluorcescent microscope after staining with aniline blue. Among the interspecific crosses, the cross between *J. curcas* and *J. integerrima* was successful with seed production. While other crosses were either partly successful or failed to produce seeds due to the existence of pre and post-zygotic barriers. The self-pollinated pollen grains of *J. curcus* recorded pollen germination of 82.46 per cent. The pollen grains produced pollen tubes which rapidly entered into the stigma, midstylar region and finally into ovary within 1 HAP (hours after pollination).

Even with abundant pollen production in the orchard, supplemental mass- pollination (SMP) can more than triple the yield of full seeds per cone in comparison with natural pollination in *Pinus elliottii* (Van Der Syde, 1971). It is recorded that, on an average, the paternal fertilization success of the SMP pollen

donors increased from 25.0 per cent in a wind-pollinated situation to 41.1 per cent after the SMP treatments in *Pinus contorta* seed orchard (Stoehr *et al.,* 2006). Adjusting for the presence of wind-pollinations in treated (SMP) ramets, the SMP efficacy was 16.1 per cent.

Jorgensen (1990) conducted experiment for pollen gene conservation in nine forest tree species through cryopreservation and tested pollen germinability. The results of the germination test only allow restricted conclusions about the ability of the pollen to fertilize the egg cell. Overall result showed that pollen of storage in cryopreservation is on par with control (-18°C), in some species, pollen stored in cryopreservation resulted in slightly higher germination.

Deutsch *et al.* (2004) reported a successful isolation, culture and plant regeneration from isolated immature pollen of poplar. Ploidy level and haploid origin of 77 calli were investigated with flow cytometry and microsatellite markers, respectively.

Conclusion

The study shows that understanding pollen handling and its techniques are very important for forester to take up any breeding programme in forest trees. Pollen morphological study shows that pollen structure/ morphology is different among the species. Seasonal variations such as temperature and moisture differentially affect the initiation and development of pollen grain. The time and rate of pollen shedding are also under the control of both external and internal factors. Study also shows that time of pollen collection is important for storage and further breeding purpose to obtain higher fruit set in trees. Pollen extraction at 21° to 27° C with 20 to 40 per cent relative humidity would be ideal. Temperature for pollen storage condition of tropical species was ranged from 4°C to -20°C for shorter time and cryopreservation for longer time. Stability during storage is related to the nature of the outer layer of the pollen wall (exine) and pollen protoplast metabolism during storage. BK germination media containing 10-30 % sucrose shows better pollen germination in forest tree species. Controlled pollination and supplement mass pollination for quality seed production is very important. Information on different pollen handling techniques helped in crossing programme of forest tree species like Salix, Popular, Eucalyptus, Jatropha as well as SMP for large scale production of quality seeds in Seed orchards of *Pinus* species. Review showed that, the work on pollen biology among tropical forest species is scanty. Furthermore, for successful breeding programme, it is necessary to workout different pollen handling techniques like collection time, drying, storage condition, proper pollen germination media and pollen application methods for each forest species to obtain genetic quality seeds in large scale.

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Seminar No. 77

Speaker : **Mr. Prajapati Dhavalkumar Rajeshbhai**	Reg. No. 1030316001
Degree : Ph.D Forestry (Agroforestry)	Course No: FOR-692
Major Adviser: **Dr. N.S. Thakur**	**V**enue: Conference Hall
Minor Adviser: **Dr. R.P. Gunaga**	Date: 31/05/2018

FODDER TREE MANAGEMENT IN AGROFORESTRY SYSTEMS

Livestock plays an important role in production of Indian agriculture supporting livelihood in the rural areas of the country. India has one of the largest livestock populations in the world (512.05 million in 2012). But numbers have been decreased 3.33 (529.69 million in 2007) % from the previous census (Anon., 2012). Our country faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% concentrate feeds (Datta, 2013) and this deficit can be accounted for the main limiting factor to improving livestock productivity (Birthal and Jha, 2005). It has been reported that land allocation to cultivation of green fodder crops is limited and has hardly ever exceeded 5 per cent of the gross cropped area (GoI, 2009). In most parts of world, especially in hills and arid regions, after the end of rainy season, animals suffer badly due to lack of protein rich diet since availability of fodder become scarce. In this case, fodder trees can play an important role in reducing the fodder shortage problem which is the cheapest source of protein to livestock. 'FODDER TREES' are the trees and shrubs mainly or partially grown to provide fodder for livestock. It includes leaves, twigs and even edible pods and barks of certain plant species. Animals need quality feed and water in order to live, grow, work or produce milk or meat. Fodder trees and shrubs become then important as a source of energy and protein to keep the animal's body healthy, improve growth rates and even increase milk and wool production (Raj and Lal, 2014).

Indian sub-continent has one of the richest in biodiversity on the globe. For instance, according to Misri (1997) Himalaya supports about 84 trees and 40 shrubs of fodder value, yet not more than 20 trees are extensively used by farmers. Tree leaf fodder is the major feed resource during lean periods. But, over exploitation and unscientific management of fodder trees has depleted this resource at huge environmental cost. In India, practice of fodder production is rarely exist, in rural areas and animals generally consume naturally grown grasses and shrubs, which are of low quality in terms of protein and available energy. They thus, heavily dependent on seasonal variations and this results in fluctuation in fodder supply round the year affecting supply of milk. Therefore, there should be an option available for producing green nutritious fodder in scarcity period when green fodder play important role in improving livestock health. Thus, identification of nutritious fodder trees and its management for fodder production with its integration into an agricultural system can fulfill the objective to make fodder available round the year.

Brief review

Oppong *et al*. (2002) studied effects of season and frequency of harvest on browse yield of two Salix species in which the total dry matter was found highest in spring season while frequency of harvest showed winter and autumn harvest as the best for getting higher dry matter biomass for both the species.

Sanchez *et al.* (2006) estimated biomass yield, growth rate and average height of *Moringa oleifera* at different planting densities and cutting interval during the first and second year after planting. The results showed that the biomass yield was found higher in high density plantation (750000) while in subsequent year it showed maximum dry biomass in 500000 plants/ha. Cutting frequency resulted in higher total dry biomass for the 75 days interval among the others intervals.

Kumar (1999) examined the effect of seasons of lopping on fodder nutrients of *Prosopis juliflora* where the data depicted that the harvest carried out in the autumn/monsoon gave higher crude protein (%) while in spring season, the leaves were lowest in crude fibre with moderate amount of crude protein (15.2 %) and higher in Phosphorus content (0.25 %).

Huda *et al*. (2016) tested the effect of fertilizer doses on the Biomass yield (kg/ha), DM yield (kg/ha) and Crude protein for two years of planting yield of *Moriga oleifera* at different year of cutting and found that overall yield of all the three parameters were found maximum when fertilized with the medium dose (90:30:15 NPK).

Saddul *et al*. (2004) collected the leaves of *Morus alba* harvested at four different stages of maturity for estimating nutrient composition and found that the DM content and crude protein yield per harvest recorded maximum when leaf harvested at 9 week while crude protein yield per year was found maximum when leaves harvested at 3and 5 week.

Kumar (2010) estimated the dry matter content (%) and crude protein (%) of bamboo leafs in relation to species and time of lopping of bamboo leaf and observed that S_3 (*Dendrocalamus parshii*) exhibited highest average dry matter (%) and S_4 (*Bambusa arundinacea*) exhibited highest crude protein (%). However, both the parameters were found higher when bamboos were lopped in February month.

Chauhan *et al*. (2014) assessed the yield and quality of annual and perennial fodder intercrops in *Leucaena* alley farming system and found that *Leucaena* (Subabul) alleys was not affected and the above ground biomass of the system was more when compared to sole fodder production of annual (maize + cowpea followed by berseem + ryegrass) and perennial Napier Bajra hybrid. The fodder productivity of perennial and annual crops was 140.2 and 110.3 t/ha in *Leucaena* alleys against the 128.7 and 98.7 t/ha in open, respectively. The *Leucaena* based silvi-pastoral model was found highly productive, which yielded fuelwood (3.52 t/ha on dry weight basis) in addition to fodder from inter-crops and *Leucaena*. Biomass yield of one hectare of inter-cropping was found equivalent to 1.45 ha by sole fodder crops. Moreover, the Subabul based fodder inter-cropping produced 15 per cent higher protein than the sole fodder crop on unit area basis.

Vennila *et al.* (2016) reported that lopping at shorter time interval i.e once in 2 months or 4 months resulted in more number of branches, leaves, leaf weight, leaf branch ratio and increased yield. Further, early lopping resulted in succulent leaves and branches which are highly suitable for the animals to consume.

Hutasoit *et al*. (2016) assessed the effect of cutting interval on yield and nutrient composition of *Morus* spp. and results showed that dry matter yield higher significant on 60 days, chemical composition on DM was higher ($P<0.05$) of 41.53 on species *M. nigra*, influence on 60 days defoliation and also added that the higher frequency of defoliation cause the lower of CP content in mulberry.

Reshma *et al*. (2016) studied the interaction effect of plant density and pruning frequency on annual fresh and dry fodder yield and leaf-stem ratio underneath coconut plantation of *Leucaena leucocephala* Lam. and found that fresh fodder biomass was higher in plants under high density with 8 week of pruning interval and dry fodder biomass and leaf:stem ratio was found in plants under high density with 16 week of pruning interval.

Chand (1998) evaluated the effect of species and pollarding height on leaf biomass (kg/plant^{-1}) and leaf nitrogen concentration (%) and found that as pollarding height has positive correlation with leaf

biomass production and leaf nitrogen concentration (%). *Morus alba* pollarded at the height of 2 m produced maximum fodder whereas *Grewia optiva* was recorded with highest crude protein content (%).

Islam *et al*. (2008) studied interaction effect of shoot tip condition and branch pruning levels on the number of leaves in new branches at different Days After Pollarding in *Sesbania grandiflora* and suggested that the severely pruned plant (both lower and upper branch pruned along with pollarded shoot tip) not only produced huge amount of shoot biomasses but also enhance the development of new shoots within a very short period.

Singh and Dadhwal (2015) estimated the biomass production (q/ha) from *Grewia optiva* and Hy. Napier under two canopy management practices from system and observed that the total biomass from silvopastoral system was higher than the sole grass crop and suggested that such systems can be practiced to produce multiple farm products.

Kaul and Ganguli, (1963) reported that among three different densities of the tree *Prosopis juliflora* 14% density under scrubland can produce more combined yield than the others.

Walker (2007) evaluated biomass production (MT ha^{-1}) of *Leucaena diversifolia* and *Leucaena leucocephala* under different spacing management and found that and found that bothe the species have performed good in close spacing (5*5 m) for producing leaf and overall biomass and suggested that both species have good potential to produce nutritive fodder.

Thakur *et al*. (2007) evaluated the effect of *Leucaena leucocephala* plant spacing on yield of herbs and effect of spacing of 4-year-old hedgerows of *Morus alba* on yield of wheat and soybean and found that all the crops were producing higher yield under control or as a sole crop.

Atta-Krah and Sumberg (1988) examined dry matter and nitrogen yield of prunings in *Gliricidia* alley cropping on a degraded alfisol and found first and second season pruning yield and nitrogen yield were chronically 5.98 t/ha, 189 kg/ha and 5.78 t/ha 173 kg/ha.

Kumar and Tewari (2001) evaluated mean annual fodder yield/tree (in kg) obtained under various lopping treatments in *Ailanthus excelsa* and observed that the heavy lopping was giving maximum yield of fodder during the experiment.

Semwal *et al.* (2002) examined the tree fodder and fuelwood available from mixed plantation and grain and by-product yields of winter season crops (wheat, mustard and lentil) and rainy season crops (rice, barnyard millet and foxtail millet) over a period of one year due to different intensities of lopping and mentioned that 100% lopping intensity can give maximum yield in terms of fodder and fuel in all the trees but 75% pruning can give higher grain and by-product yields among others.

Rai *et al*. (2007) studied the effect of pruning on under-storey forage, tree fodder and fuel-wood production under *Anogeissus pendula* based silvopastoral system for three years and found that increased pruning intensity increases the dry leaf fodder, fuelwoo and dry grass forage yield.

Varsha *et al*. (2017) estimated harvested dry fodder biomass and crude protein yield over 2 year period from different fodder production systems and observed that sole hybrid napier produced highest dry fodder mass while sole *Morus* produced highest crude protein but their combination in pasture system produced comparable amount of dry fodder biomass and crude protein.

Seema *et al*. (2011) determined the effect of biofertilizers on survival (%), fodder production, crude protein and fiber content of tree species in silvopastoral system and found that the treatment of inoculation with N fixers + AM consortia with vermicompost (*Rhizobium* + AMF +VC) significantly improved survival (%), fodder production and fodder quality.

Conclusion

- In today's era, fodder demand for livestock is increasing day by day and the resources that we have are in limited quantity but it can be if properly managed, the fodder demand can be mitigated through the use of different production technology of agroforestry which will make fodder available all round the year and ultimately improve the social condition of the farmer.

- On farm evaluation and demonstration of existing as well as refined technologies should be carried out to narrow the gap between yields realized on farmers' fields and those on research stations.
- Several studies revealed that good management practices are essential for improving fodder quality and quantity. It requires selection of productive species having good nutritional quality which can be managed in either suggested way. It is observed from the different studies that the cutting cycle, cutting height, season and many other practices have effect on quality and quantity of fodder. For lopping intensities it can be suggested that it should have minimum effect on the tree and have high leaf production with high leaf:stem ratio.
- It has been seen from the studies that the early lopping gives maximum fresh leaves production and low woody twigs but gives less dry matter content compared to delayed cutting due to high moisture content. However they are high in crude protein (%) than leaf harvested in delayed lopping. Therefore, it has been advised that fodder should be harvested before they Hard woody twigs.
- In the arid regions of India, the species like *Zyzyphus mauritiana, Ailanthus excelsa* and *Prosopis cineraria* are to be included at various spacing in agroforestry system that can produce fodder in dry period.
- In the northern and north-eastern regions of India, nutritive species having high crude protein like *Morus alba* and *Grewia optiva* should be planted along terraces or can be pollarded which has the capacity to produce good quantity of fodder in dry winter period.
- In southern India, trees like *Leucaena leucocephala*, *Gliricidia sepium*, *Sesbania grandiflora* and *Moringa oleifera* can be managed in various agroforestry systems *like* alley cropping, to enhance productive capacity of farm for fodder.
- It has been suggested that the regions where frequent drought occurs should have to focus on forage production through three-strata forage system or protein bank rather than agriculture because agriculture crop can't survive adverse condition but trees can.

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Seminar No. 78

Speaker : **Mr. Ravindra Kumar Dhaka**	Reg. No. 1030316002
Degree : Ph.D Forestry (Forest Genetic Resources)	Course No: FOR-692
Major Adviser: **Dr. R.P. Gunaga**	**V**enue: Conference Hall
Minor Adviser: **Dr. Manmohan J Dobriyal**	Date: 07/04/2018

VARIABILITY STUDIES IN WOOD ANATOMICAL PROPERTIES FOR PULP AND PAPER AMONG IMPORTANT SHORT ROTATION TROPICAL TREES

Short rotation tropical trees are very important for fast growth as well as early harvesting and it fulfill the demand of pulp and paper, fuel wood and local energy. Apart from this, SRF also provides a source of income to farmers, provide ecological security and reduce the risk of climate change and global warming effect as well as it increases carbon sequestration potentiality, soil carbon and soil biodiversity. There are many properties of wood including fibre characters that are under genetic control, most of which are essentially independent except for those characters (cell wall thickness and specific gravity) that are actually dependent on each other. World demand for paper and paperboard is predicted to grow to 482 million tons in 2030 which equals an increase of 1.1 per cent per year (Anon., 2015). India's paper demand is expected to rise 53 per cent by 2020 and the demand for wood in paper industry is set to increase from current 13 million tonnes to an estimated 20 million tonnes by 2020 (Anon., 2014). Tree improvement plays a vital role in quality and quantity of wood production. While selection of superior genotypes for large scale production of pulp wood, inclusion of wood anatomical properties is essential to achieve maximum pulp production as well as higher economic gain. In the present study, genetic variation reported in various wood anatomical properties among several short rotation tropical tree species have been overviewed and presented. Details of these studies are discussed below.

Brief review of research works

Acacia auriculiformis

Anoop *et al.* (2012a) studied the provenance variation in *Acacia auriculiformis* for wood anatomical characteristics in Kerala. The data showed that anatomical parameters such as Vessel diameter, Ray height, Ray width, Vessel frequency, Ray percentage, Parenchyma percentage and Fibre percentage recorded to be higher in Kings Plain provenance than Orchard Melville provenance. However, it was reverse in the case of vessel percentage.

Hasegawa *et al.* (2009) studied growth and fiber length variation among provenances of *A. auriculiformis* in Central Java, Indonesia. Result showed that, in Queensland-Australian region, fiber length ranged from 1.05 to 1.09 mm, whereas in Papua New Guinea region, it ranged from 1.09 to 1.11 mm.

Acacia mangium

Nugroho *et al.* (2012) characterized seven anatomical parameters among five different provenances of *Acacia mangium.* Result showed that there was no significant variation among studied provenances for fiber wall area, fiber wall thickness, fiber diameter, vessel lumen area, vessel diameter, vessel frequency and wood density.

Whereas study conducted by Hasegawa *et al.* (2009) at Central Java, Indonesia showed that there fiber length ranged from 1.03 to 1.10 mm among 7 provenances in Queensland-Australian region and 1.05 to 1.09 mm among 8 provenances in Papua New Guinea region.

Jajo (2015) evaluated 11 *A. mangium* provenances for fiber morphology and fiber indices in Kerala. Result showed that all these parameters showed significant variation among provenances. For instance, fiber length ranged from 901.12 (Oriomo WP) to 1091.05 µm (Kuranda) and it attributed to higher heritability (82.63%) and genetic gain (42.01%). Similarly, slenderness ratio also recorded highest heritability (87.08 %) and genetic gain (86.69 %) values.

Anoop *et al.* (2012a) also studied provenance variation for wood anatomical properties among *Acacia mangium.* In eight studied parameters, only vessel diameter showed significant variation among provenances and it ranged between 171.22 and 256.18 µm.

Acacia hybrids (*Acacia mangium* and *Acacia auriculiformis*)

Yahya *et al.* (2010) compared fibre properties of seven-year-old Acacia hybrid with *A. mangium* and *A. auriculiformis*. Seven out of thirteen wood anatomical parameters showed significant variation between hybrid and *A. mangium* and/or *A. auriculiformis.* Most of the values of hybrid stand in between values of their parents (*A. mangium* and *A. auriculformis*). Interestingly, fibre length and proportion of fibre values were significantly higher than parents.

Similarly, Kim *et al.* (2008) also studied variation in fiber length and vessel length among six natural acacia hybrid clones in Bavi, Vietnam. Fiber length ranged from 0.86 to 0.93 mm and vessel length ranged from 0.23 to 0.25 mm among six hybrid clones of Acacia.

***Casuarina* species**

Nicodemus *et al.* (2015) examined fiber morphological characteristics along with Runkel ratio among four species of *Casuarina* using different provenances (*C. cristata, C. cunninghamiana, C. equisetifolia* and *C. junghuniana*) in IFTGB, Coimbatore, Tamil Nadu. Among four species, *C. cristata* had shorted and thinnest fibres making its Runkel ratio of 1.07. *C. equisetifolia* and *C. junghuniana* possessed the longest and broadest fibers with thicker cell wall compared to other species with high Runkel ratio of about 1.3.

***Eucalyptus* species**

Miranda and Pereira (2002) studied the fibre morphology of 4 provenances of *Eucalyptus globulus* from three sites at the age of 9 years. Variation between provenances as well as between sites for fibre length, cell wall thickness and lumen diameter were significant. Provenance 23 of *E. globules* performed better for these parameters in Furadouro site.

Dutt and Tyagi (2011) evaluated various fibres characteristics in 11 different *Eucalyptus* species including four hybrids. Longest fiber length was observed in *Eucalyptus grandis* (1.06 mm) than other species. *Eucalyptus grandis, E. alba* and E. –471 (hybrid) recorded less than one Runkel ratio.

Pirralho *et al.* (2014) studied wood anatomical characteristics of nine *Eucalyptus* species. Fiber length and width found to be highest in *Eucalyptus viminalis,* whereas highest vessel length and wall thickness was

reported in *Eucalyptus globulus.* Runkel ratio was found less than 1 in *Eucalyptus viminalis, E. camaldulensis* and *E. tereticornis*.

Anoop *et al.* (2012b) evaluated 13 clones of *Eucalyptus camaldulensis* for various vessel and fibre parameters with Runkel ratio. Maximum fiber length was recorded in clone-191, maximum fiber and lumen width recorded in clone-76. Wall thickness was found to be maximum in clone-1. Runkel ratio ranged between 0.56 to 0.70.

Quilhó *et al.* (2006) compared fibre length, width and wall thickness in woods originated from clones and seeds in eucalyptus hybrid urograndis (*E. grandis* × *E. urophylla*). Result showed that clonal material resulted in higher values than seed origin.

Ramirez *et al.* (2009) studied clonal variation for fiber wall thickness, fiber and lumen diameters among 14 clones of *Eucalyptus globulus.* Maximum fiber diameter and wall thickness was found in clone-N, whereas highest lumen area was recorded in clone-F.

Rao *et al.* (2002) also observed highest values of fiber length, fiber diameter, wall thickness and vessel frequency in clone-3 as compared to other four clones of *Eucalyptus tereticornis.* Maximum lumen and vessel diameter was found in clone-4 and clone-6, respectively.

Leal *et al.* (2003) observed vessel parameters among 17 clones of *Eucalyptus globulus* from two clonal trials. Variation between sites for these parameters was recorded. Maximum vessel area was observed in clone-1 in Nogueirões site and clone-11 in Carvalhinho site. Clone-17 and clone-16 showed highest vessel numbers and vessel coverage in both the sites than other clones.

Behera (2015) studied clonal variation in wood anatomical properties among 20 *Eucalyptus* clones at NAU, Navsari. Highest fiber length and diameter was found in Clone-15 (JK02), whereas maximum lumen diameter and wall thickness was recorded in clone-20 (B288) and clone-6 (P316), respectively. Maximum vessel length and diameter was obtained in clone-7 (P498) and clone-18 (B2153), respectively.

Gupta (2012) studied fiber characteristics among10 clones of *Eucalyptus* at NAU, Navsari. Highest fiber length and width along with wall thickness was reported in clone BCM-2045 and maximum lumen width was recorded in clone BCM-2153.

***Populus* species**

Pande and Dhiman (2011) evaluated 10 commercial clones of *Populus deltoids* for various wood anatomical properties. Maximum fiber length was found in clone W-39 and highest fiber width and wall thickness was recorded in clone G3. Clone Udai and W22 registered highest vessel length and diameter, respectively.

Ivkovich (1996) investigated genetic variation in wood properties among and within 3 provenances of balsam poplar. Longest fiber and vessel was observed in North Wisconsin provenance. Broad sense heritability for fiber length (0.13 to 0.30) and Vessel length (0.11 to 0.35) was lower in all the three location.

Pande *et al.* (2014) compared growth and wood anatomical traits among 144 progenies in *Populus deltoides*. Variation in fiber length (1077-1322 µm), fiber diameter (22.55-27.22 µm), wall thickness (2.78-4.66 µm), vessel length (461.44-607 µm) and vessel diameter (95.55-121.22 µm) was recorded among 144 progenies. Broad sense heritability, genetic gain and genetic advancement were found to be highest in vessel length than other traits.

Leucaena leucocephala

Pande *et al.* (2013) evaluated 28 populations of *Leucaena leucocephala* from different geographical locations of Andhra Pradesh, Tamil Nadu and Orissa. Wide variation was recorded for many of the anatomical parameters. Maximum fiber length, fiber width, wall thickness, vessel length and vessel length were registered by KVP-ONG, KG-KHM, LP-GUN, ITC-BMC-182 and AMR-KHM clones, respectively.

D´ıaz *et al.* (2007) compared fiber length in one and two year aged wood samples from five *Leucaena* genotypes. Highest fiber length was observed in *L. leucocephala* var. I and lowest in *L. collinsii.*

***Salix* species**

Monteoliva *et al.* (2005) studied genetic variability in fiber length among 6 clones of Salix species. Longest fibre was recorded in Americano clone than others. Significant difference for Clone × Site effect was also recorded. Heritability value was 0.32 for fibre length.

Genetic Parameters in short rotation species

Review showed that genetic parameters like heritability, genetic advance and genetic gain were varying among different species as well as different genotypes/clones. Most of the study showed that fiber properties of wood are under genetic control, which determine the product quality (Zobel and Jett, 1995). Collected literature shows that, in most of the species, heritability values for fiber length ranged from low to medium. Interestingly, species like *Acacia mangium* and *Populus tremuloides* recorded highest heritability values (> 0.80 H^2) with genetic gain of about 42 and 74 per cent, respectively.

Conclusion

In the present scenario, short rotation tropical trees are very important for fast growth and early harvesting. The study of wood anatomical properties is prerequisite for pulp and paper wood species and important for crop harvesting at optimum rotation. The demand of pulp and paper can be fulfilled by introduction of genetically improved clones/ varieties of fast growing trees which can be harvested within 2 to 5 years period. Wood anatomical screening is one of the important criteria while selecting a species for high quality pulp and paper and bringing it to the main stream of industries as a raw material. Most of the fiber properties of wood are under genetic control that helps in determining the product quality. Fiber length is one among them. Cell wall thickness and lumen diameter are also important characters which indirectly effect on the bonding strength and quality of the paper. Studies showed that there is a greater variability in fiber length; for instance, fiber length varied from 831-1036 µm in *Eucalyptus globulus*, 781-1057 µm in *Eucalyptus camaldulensis*, 1048-1322 µm in *Populus deltoides*, 940 to 1100 µm in *Acacia mangium*. In some species, like *Acacia mangium* and *Populus tremuloides*, the higher heritability values for fiber length showed the character under strong genetic control. Fiber indices *viz.* Runkel ratio, flexibility ratio, slenderness ratio and rigidity coefficient are important for pulp and paper wood to deciding the quality and quantity of pulp in paper making. Some of the studies showed significant variation for wood fiber indices like Runkel ratio in studied short rotation pulp and paper wood species. The present study documented the genetic variation in various wood anatomical properties among short rotation tropical tree species that helps in further selection, evaluation and breeding to achieve higher productivity potential for pulp and paper. Further, characteristics such as fiber length, cell wall thickness and lumen diameter may be incorporated in priority along with other bio-chemical properties of wood while selection of superior genotypes for pulp and paper making.

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