A COMPENDIUM OF FORESTRY PG SEMINARS

ACADEMIC YEAR (2018-19 to 2020-21)

COLLEGE OF FORESTRY
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI - 396 450

"A substantive, thorough, sophisticated literature review is a precondition for doing substantive, thorough, sophisticated research" (Boote and Beile, 2005)

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Dr. P.K. Shrivastava
Dean
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FOREWORD

Forestry education in India as a part of NARES began in 1985 in SAUs whereas in Navsari Agricultural University under the aegis of ASPEE College of Horticulture and Forestry (ACHF), B.Sc. (Forestry) programme started in 1988. 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 Biotechnology, Medicinal and Aromatic Plants, Wood Science and Technology, Watershed management, *etc*. As per V Dean's Committee recommendation, the nomenclature of PG programme has been modified and providing PG degree in Forestry with specialization in SAF, FBT, FPU, NRM and WS. 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 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.

(P.K. Shrivastava)

Credit Seminar Substantativeness

"A substantive, thorough, sophisticated literature review is a precondition for doing substantive, thorough, sophisticated research" (Boote and Beile 2005), quote suites very well in professional courses of agricultural sciences as it involved testing of aspects which already well explored. 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 required to an 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. Authors of manuscripts treat writing a literature review as a routine work or a mere formality. But a seasoned one knows the purpose and importance of a well-written literature review. Since it is one of the basic needs for researches at any level, they have to be done vigilantly. Only then the reader will know that the basics of research have not been neglected. 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. 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 requires proper planning. Unlike the other seminar/ symposiums where one present his or her own research and get interacted, in credit seminar presenter review others works and summarisng the presentation which would 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 in 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. Seminar though the part of academic programme but it also helps in personality development and an opportunity to show your scientific acumen with your peers. This also addresses the stage anxiety and fear if person is well prepared to deliver the content and deeply studied 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 as well 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 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. Narender Singh Thakur

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2018-2019

Seminar No.1

Speaker: Mr. Baldaniya Jayesh Kumar B.	**Reg. No.** 2030317001
Degree: M.Sc. Forestry (Silviculture & Agroforestry)	**Course No:** FOR 591
Major Advisor: Dr. D. Nayak	**Venue**: Room No. 101
Minor Advisor: Dr. D. P. Patel	**Date:** 29/09/2018

AILANTHUS BASED PRODUCTION SYSTEM

Introduction

Ailanthus is derived from *ailanto,* an Ambonese word probably meaning **"tree of the god" or "tree of heaven"** is a genus of trees belonging to the family Simaroubaceae. It is native from South-East Asia to Australia. The number of living species is disputed with some authorities accepting up to ten species. Among the reported species, *A. excelsa* (Ardu) is very extensively used by the cultivator in the tropical countries. It is fast growing in nature and cultivated in many parts of India. The plant is believed to be native of India and Sri Lanka, also exotically found in other tropical region. The plant is known for its high economical and commercial importance (Anon., 1985). It is a large deciduous tree, 18-25 m tall; trunk straight; 60 to 80 cm in diameter; bark light gray-brown and rough on large trees, aromatic to slightly bitter in nature. Further, *A. excelsa* is an important agroforestry tree species in arid and semi-arid regions due to its wider adaptability, fast growth and higher tolerance to biotic and abiotic stresses, supplying leaf fodder and timber for plywood (Kaushik *et al.* 2016). Therefore, *A. excelsa* has been chosen as the major and important species for the seminar.

Brief review of research work

Production of quality planting material

Bhasotiya and Tandel (2017) concluded that maximum germination percentage of *A. excelsa* was noted in Soil: Sand mixture of 1:1. However, number of leaves per plant, shoot length, collar diameter, seedling survival percentage, fresh and dry weight per plant of the seedlings were registered maximum in potting mixtures of Soil: Sand: FYM @ ratio of 2:1:2 while maximum root length was found in Soil: Sand: FYM @1:2:2 ratio. Among all these mixtures, Soil: Sand: FYM in 2:1:2 ratios were found best for most of the growth parameters.

Gehlot *et al*. (2014) conducted an experiment on sowing of *A. excelsa* seeds in different growth substrates in varying depths. They found that germination percentage, germination period and germination value were highest when seeds were sown at a depth of 0.5 cm and lowest at 1.5 cm.

Rawat *et al*. (2001) concluded that the maximum mean germination per cent (45.3%) of *A. excelsa* was obtained at 35°C. The interaction effect of temperature and media on germination per cent was significantly higher in between substrata of 35^0C (*i.e.* 45.5%). Further, the mean germination time was significantly higher at 25^0C.

Masilamani (2009) conducted an experiment on effect of soil pH and organic matter on germination and quality of *A. excelsa* seedling. The highest germination of 51.2% was recorded in the media mixture of red soil + sand + farmyard manure (2:1:1) at soil pH is 7.

Spacing and Nutrient Management

Jat *et al.* (2010) conducted that genotype sel 9 of *A. excelsa* performed maximum in respect of plant height (251.33 cm), crown diameter (8.85 cm), leaf dry matter accumulation per plant (0.754 kg), plant growth rate (4.189 g /day/ plant)in semi-arid ecosystem of Rajasthan.

Gupta (1995) concluded that the application of 18 g nitrogen and 3 g phosphorus per plant gave maximum height, collar circumference and crown diameter at 1, 2 and 3 year of age in *A. excelsa*.

Bimlendra and Toky (2006) concluded that the survival and growth of seedlings of six multipurpose tree species in saline soil was highest survival for *D. sissoo*. Further, *A. excelsa* can grow at 52 % survival in the saline condition as well.

Kumar *et al.* (2001) revealed that plant height, diameter at breast height (DBH) and crown width were found non- significant for population density and fertilizers level as well as for interaction effect. However, leaf area for population density was significant and non-significant for fertilizer levels. Maximum growth characters like plant height (3.41 &3.43 m), DBH (6.42&6.30 cm), crown width (1.69 &1.72 m) and leaf area (3.93 &3.07) were recorded for density (3333 &2500, 1600, 3333trees/ha) and fertilizer level (50:25:25, 50:25:25, 100:50:50,150:75:75 kg/ha /year) respectively.

Agroforestry

Rajalingam *et al.* (2013) revealed that minimum reduction in plant height (5.1 & 5.4 cm), number of branches (6.4 & 6.4) were found at 30 and 90 days after transplanting of cluster bean where as yield per plant and hectare (tonnes) were reduced respectively 7.68 and 7.82 percent when intercropped under *A. excelsa.* They also studied the influence of intercrops on growth of tree and found that tree height (0.53 m) and DBH (1.32 cm) were maximum with cluster bean as compared without intercropped trees.

Kaleeswari (2015) concluded that fodder cow pea produced higher green fodder (7.08 t/ha) as compared to other crops intercropped with *A. excelsa* showed highest land equivalent ratio (0.84) as well.

Sharma *et al.* (2009) found that *A. excelsa* + *Cenchrus* silvipasture system produced highest biomass of 86.37 q/ha as compared to other system.

Kaushik (2016) investigated the yield of pearl millet and cluster bean crop and was not affected by different spacing of *A. excelsa* as compared to control (without trees) during the 1st year of plantation. However, average grain yield and straw yield of pearl millet was 32.32 q/ha and 56.56 q/ha in 10 × 20 m spacing. Further, grain yield and straw yield of cluster bean was maximum 10.84 q/ha and 12.00 q/ha at 10 × 6.5 m spacing.

Meena *et al.* (2005) evaluated the effect of tree densities and inter-cropping on growth parameter of *A. excelsa* in silvipasture system and noticed that tree height (7.9 m), collar

diameter (72.15 m) and canopy diameter (4.17 m) all together found higher in lowest plant density of (25 tree/ha).

Rajalingam *et al*. (2017) found maximum yield of Chinese amaranth (8.48 t/ha) which was at par with Chinese spinach (8.46 t/ha) while studying the effect of *A. excelsa* on yield of intercrops in western zone of Tamil Nadu. However incase of reduction of yield was recorded minimum Chinese spinach (11.15 %) as compared to other intercrops. Further, the study revealed that growth of *A. excelsa* (height and DBH) was found maximum in the intercrop with Palak.

Sharma (2015) revealed that *Prosopis cineraria* based system showed maximum grain yield (778 kg/ha), straw yield (2025 kg/ha), green fodder yield (13.17t/ha), dry fodder yield (4.80t/ha) and cluster bean equivalent yield (1.04 t/ha) as compared to other system. Incase of crops cluster bean exhibited maximum grain yield (818 kg/ha), straw yield (2220 kg/ha) and CEY (1.31 t/ha) whereas sewan grass with highest GFY (14.40 t/ha), DFY (4.68 t/ha) and CEY (0.86 t/ha).

Fodder production and utilization

Kumar and Tewari (2001) found maximum yield of fodder (5.93, 4.22, 3. 05) for three years under the treatment of heavy lopping in the 5 year old plantation of *A. excelsa* as compared to slight and moderate lopping.

Tewari *et al.* (1995) stated that produced maximum green fodder of 85 kg and 200 kg / tree at 9 year and 10 year (and above) respectively in the *A. excelsa*.

Raghuvansi *et al.* (2006) studied the nutrient intake and digestibility in ruminants by feeding leaves of different plant species; they found that *A. excelsa* leaves exceed in digestibility and nutrient value of diets as compared to pearl millet stover based diet, *Azadirchta indica* and *Albizia lebbeck* leaves.

Arya (2006) evaluated the mean yield of *C. ciliaris* dry matter (kg/ha) and total fodder yield (kg/ha) under three tree species silvipastoral system in the Nagaur district of Rajasthan and found that both the grass yield (1843.5 kg/ha) and the total fodder yield (3633 kg/ha) were found maximum under the *Z. mauritiana* which is at par with *A. excelsa* based silvipasture system.

Deori and Khanikor (2015) evaluated the larval duration (days), larval weight (gm), effecting rate of rearing (%), cocoon weight (gm), shell weight (gm) and pupal weight (gm), pupal durayion (days) under various sericulture production system. They found that castor as the best host plant for rearing of Eri silkworm. However, *A. excelsa* and *A. grandis* can be used as secondary host during dearth period of castor.

Environment

Ulman and Avudainayagam (2012) investigated carbon content (%) in *A. excelsa* and observed that stem wood (45.50), branch wood (38.00), leaf (35.30) and root (41.80) recorded maximum at the three years of plantations. In addition, they also reported that mean soil organic carbon at 30 cm depth (%) and (t/ha) were maximum during this period.

Varadharajan *et al.* (2010) studied the effect of elevated CO_2 on *A. excelsa* seedlings and reported that in elevated CO_2 condition performed better by all parameters as compared to ambient CO_2 level.

Pest and Disease

Anon. (2012) reported that the major insect pest and diseases like *Ailanthus defoliator* and *Ailanthus web worm leaf spot* and *powdery mildew* can be control with proper chemical and biological control measures.

Economics

Rajalingam *et al.* (2013) estimated the economics of *A. excelsa* based silvihorticultural system and reported that highest B: C ratio of 3.02.1 was obtained from brinjal intercrops.

Sharma (2015) evaluated the economic benefit of different tree species, crops and grass; found highest B: C ratio of 1.78 and 2.05 in *Prosopis cineraria* and *Cyamopsis tetragonoloba* respectively.

Rajalingam *et al.* (2017) evaluated the economic return of *A.excelsa* based silvihorticultural system and reported that the highest B:C ratio of 3.08 was obtained from Chinese spinach and lowest from tropical amaranthus.

Ali (2001) evaluated the economic return of *A. excelsa* in linear plantation and block plantation at different ages, the benefit/cost ratio was highest for block plantation (3.76) at the age of 15 years.

Anon. (2016) reported that the net return from *A. excelsa* intercropped with green gram was highest (Rs. 76024/ha) in agrisilviculture system over other sole.

Conclusion

From the forgoing discussion, it can be concluded that *Ailanthus* is suitable for different production systems in singly or in combination. *Ailanthus* is produced as timber, poles, fuel wood; leaves are highly palatable protein, nutritious fodder for small ruminants and secondary host for eri silkworm. Further, *Ailanthus* based agroforestry system provided highest net return than sole cropping system.

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Seminar No. 2

Speaker: Chaudhary Vrushali Vijay	**Reg. No.** 2030317002
Degree: M.Sc. Forestry (Silviculture & Agroforestry)	**Course No:** FOR 591
Major Advisor: Dr. M. J. Dobriyal	Venue: Room No. 101
Minor Advisor: Dr. M. B. Tandel	**Date:** 29/09/2018

SILVICULTURE AND AGROFORESTRY OF MEDICINAL TREES

Introduction

Silviculture being the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of state and society on a sustainable basis through the application of *silvics* or applied forest ecology has an important role in forest production system. On other hand agroforesty is a sustainable land use management system integrating the trees with crops and/ or livestock in some form of temporal or spatial agreement in order to increase the productivity of per unit land. A medicinal tree is a plant from which substances of medicinal value can be distilled or extracted in the form of resin, gum, oils, flower, fruits, tannins, alkaloids. India's rich natural wealth and species diversity of such trees has been a key element in their extensive use in traditional herbal treatment systems. Tree species are the source of one or many formulations used in Ayurvedic,

Unani and Homeopathic systems of medicines. These are important source of alkaloids, glucosides, essential oils and other physiologically active organic compounds used in treating various ailments. *Commiphora wightii, Taxus baccata, Oroxylum indicum, Nothapodytes nimmoniana, Boswellia serrata, Pterocarpus marsupium, Terminalia bellerica* and *Terminalia chebula* are the prominent medicinal trees found in natural forest landscape whereas *Acacia catechu, Azadirachta indica, Ailanthus excelsa, Albizia lebbeck, Cinchona ledgeriana, Gmelina arborea, Terminalia arjuna, Morus indica, Aegle marmelos, Emblica officinalis, Morinda citrifolia, Syzygium cumini, Tamarindus indica* and *Grewia optiva* are some important medicinal trees grown in agricultural landscape or Agroforestry system.

The knowledge and practices of silviculture and agroforestry of these medicinal trees are important for their conservation and sustainable utilisation for mankind. Most of the medicinal trees found in wild and their regeneration, establishment, tending and harvesting done traditionally as timber crops which need a new approach. Under agroforestry many of medicinal trees mentioned are grown as MPTs rather exclusively for medicinal hence their management require different way to cater the need of medicinal products. Very limited information pertaining to the cultivation of medicinal trees in agroforestry systems exclusively for medicinal product is available. Therefore there is need for proper review of the silviculture and agroforestry of medicinal trees for better utilisation of the resource. Some of the studies are elaborated here.

Brief Review of research work:

Silviculture of medicinal trees

Pande *et al.* (2004) studied the phenological studies on *Azadirachta indica* of Satpura and adjacent agro-climatic zones of Madhya Pradesh and found flowering initiated during February in Satpura & Vindhya climatic zones but in Narmada valley it occurred in late March.

Singh *et al.* (2011) studied the effect of method and budding height in bael (*Aegle marmelos*) in which minimum days (13.42) were noted for bud sprouting while maximum bud sprouting (95%) was obtained with patch budding at 5cm height.

Panchbhai *et al.* (2006) studied the soft-wood method of propagation on different age of rootstocks to find out suitable age of rootstock and time of soft-wood grafting for commercial propagation of *Emblica officinalis* in which maximum diameter (0.52 cm) of rootstock was recorded in 10 months old rootstock.

Gupta *et al. (*2017) studied effect of vegetative propagation techniques through budding and grafting of Bahera (*Terminalia bellerica)* in which the greater plant height was recorded in cleft grafting (48.5 cm) in the month of July.

Sharma and Joshi (2008) studied the propagation of *Taxus baccata* through seed at Kalika in district Almora in Uttarakhand in which germination percent increased to 40% after 18 months of sowing in nursery bed.

Kurde *et al*.(2012) reported seedling growth improvement in *Nothapodytes nimmoniana* using different sizes of container found. Maximum seedling height (18.48 cm), basal diameter (5.39 cm), root length(24.18 cm), fresh biomass (7.33 g) and dry biomass (2.70 g) in bigger size container T_3 (10" x 14") than others.

Mirgal *et al.* (2016) studied seed size and its influence on germination, seedling growth and biomass in *Saraca asoca* (Roxb) in which maximum fresh weight and dry weight (6.30g & 2.17 g respectively) was obtained from large sized seeds.

Bhoomika *et al.* (2017) reported the plant growth and yield in Noni (*Morinda citrifolia*) as influenced by integrated nutrient management practices where treatment T_5 (50:225:50 kg/ha, NPK-50% of recommended P through bone meal) registered maximum fruit yield (35.83kg/tree & 39.81 t/ha) and maximum fruit weight (35.83 g).

Anonymous (2011) studied the nursery technique for sustainable plantations of Guggul (*Commiphora wightii*) in arid region (Kachchh) of Gujarat in which maximum seedling height (16.24 cm), collar diameter (19.91mm), number of branches (3.73) and number of leaves (4.87) were observed in 117 days old sapling.

Bajpai *et al.* (2006) studied the effect of time, seed depth and seedling growth in *Buchanania lanzan* where 1 cm depth was found best in all monthly sowing while highest germination recorded in month of June-July (70.3-71.3%) which gradually reduced to 50% sowing after year. The height after 180 days recorded maximum in March sown seeds (8.30cm) and collar diameter (1.76mm).

Ramkumar and Anuja (2017) investigated the effect of different planting density on growth parameters of moringa (*Moringa oleifera*) in which wider spacing (120×120 cm) resulted maximum plant height (143.85 cm), number of branches (7.10), number of leaves (36.47) and stem girth (12.28 cm).

Agroforestry of medicinal trees

Pandey *et al*.(2011) reported the performance of gram (*Cicer arietinum*) under neem based agroforestry system in semi-arid region in which maximum plant height (54.03 cm), number of branches per plant (12.15) and number of pods per plant (27.43) were recorded in control. Neem trees also improved the organic carbon and available N,P and K as compared to area without trees.

Kumar *et al.* (2015) investigated the growth and yield of *Vigna radiata* L. under *Terminalia arjuna* and *Mitragyna parvifolia* based agrisilvicultural system in which maximum grain yield per plant (3.56 gm) of green gram was recorded in

K-851 in T_0 (Control) while minimum (1.30 gm) in Pusa Vishal (V_1) under *Terminalia arjuna*.

Lata *et al.* (2014) studied integrated nutrient management in Aswagandha (*Withania somnifera* L.) under tree based cropping systems in drylands where C_1(Sole cropping) of aswagandha yielded maximum root yield (442.5kg/ha) and withanolide content (0.43%) as compared to C_2 and C_3 (Aswagandha intercropping in *Emblica officinalis* & *Terminalia chebula*).

Sharma *et al.* (2010) evaluated the suitable agroforestry system for quality forage in semiarid regions. The estimated protein yield was observed in range of 5.21 to 9.29 q/ha in association of different medicinal valued tree species and 0.87 q/ha to 1.68 q/ha in open field conditions.

Sharma *et al*. (2005) reported allelopathic effects of some newly developed/identified strains of Harar (*Terminalia chebula*) on germination and growth of commonly grown cereals, pulses and vegetable crops under laboratory conditions in which seed germination, shoot and root length were found to be affected by leaf leachates of different strains of Harar.

Panwar *et al*. (2011) studied the performance of rice under agrisilvicultural system in terai zone of West Bengal in which paddy height (70.18 cm), number of panicles (9.62), biological yield (10.26 t/ha) and grain yield (3.79 t/ha) was found maximum under Salix followed by Arjuna.

Singh *et al.* (2018) studied the growth and yield attributes of *Melia composita* and *Emblica officinalis* based agri-silvi-medicinal agroforestry in degraded lands where ashwagandha, sarpagandha, masoor and groundnut produced higher or equal yield under *Emblica officinalis* than open field.

Korwar *et al.* (2006) studied the effect of different tree species where castor and green gram with *Emblica officinalis* produced seed yield (10.77 q/ha and 10.60q/ha), stover yield (18.11q/ha and 19.45q/ha) and harvest index (37% and 35%) respectively. The harvest index was recorded 30% in castor and 36 % in green gram with sole cropping.

Korwar *et al.* (2006) studied the effect of different intercrops on growth of Aonla. Plant height, stem girth, canopy spread and volume were more with mothbean-fenugreek and mothbean chickpea.

Conclusion

Medicinal trees are a major resource base for the traditional medicine and herbal industry providing livelihood and health security to a large segment of Indian population. The silviculture and agroforestry of medicinal trees is not specifically defined but some of the practices are applicable for their adoption for better growth and yield. Local climate affects growth and phenology of Neem. Neem trees improved the organic carbon and available N, P, K as compared to area without trees. Budding and grafting is mostly applied *Aonla, Harad, Beheda* and *Bael* trees. Under main silvicultural practices of regeneration germination studies (in *Taxus* and *Chironji*) are important to raise the nursery for quality seedlings are important along with plantation establishment at a proper spacing. An appropriate *Neem, Arjun, Ashok, Harad, Bael* and *Aonla* based agri-silvi-medicinal system can enhance the productivity of the land and soil quality. There is a scope for increasing the productivity of noni in commercial cultivation with the application of organic and inorganic nutrients. *Tamarindus indica* and *Acacia senegal* based agroforestry systems may become economic, once these species start yielding. Exploration of the silvicultural characteristics of medicinal trees for better utilization in farm forestry is very essential. There are many medicinal trees with high therapeutic values yet to studied in context with their silvicultural practices and their further inclusion in agroforestry systematically for commercial production.

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Seminar No. 3

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NUTRIENT MANAGEMENT IN VEGETABLE CROP BASED AGROFORESTRY SYSTEM

Introduction

Vegetables constitute an important component of a balanced diet for human. They are rich in protein, minerals, carbohydrate, calcium, iron, phosphorus and all vitamins. The growth, yield and quality of vegetables are largely dependent on number of interacting factors, amongst

them NM system is the most crucial as well as basic factor and is found to exert a great influence not only on growth, yield and quality of vegetables but also for obtaining sustained productivity. Growing vegetable crops under agroforestry is a good alternative for production especially under limited resources. Sustained soil productivity and fertility in agroforestry system for higher crop yield and better quality can be achieved through nutrient management.

BRIEF REVIEW OF RESEARCH WORKS

BRINJAL

Sondarva *et al*. (2018) studied the effect of INM on growth and yield components of brinjal under teak based silvi-horticultural systems in south Gujarat region using 14 treatments and found significantly maximum plant height and number of branches per plant in 100% RDF in open condition. Similarly, various yield parameters viz., number of fruits per plant, fruit circumference, fruit length, average fruit weight and yield were also recorded significantly maximum in 100% RDF in open condition. The same treatment was remained at par with 75 % RDF along with different organic manure for majority of growth and yield parameters of brinjal in teak based silvi-horticultural system.

Varsha (2017) performed an experiment to see the effect of bio-fertilizer on the number of flowers and fruits of brinjal under karanj based agroforestry system. The number of flowers and fruits were recorded maximum in 75%N and 75%P + Azotobacter + PSB.

CHILLI

Soreng and Kerketta (2007) conducted an experimental trial consisted of 18 treatment combinations comprising of 3 different varieties of chilli for the parameters of number of flowers and number of fruits. The overall best variety and treatment noticed was (Chilli G-4) and 100% poultry manure. Maximum number of flowers per plant was recorded in variety V2 under 100% poultry manure. Moreover, significantly maximum number of fruits per plant of chilli was reported same variety under 100% poultry manure under subabul based horti-silviculture system.

Bhatt (2015) performed an experiment to see the effect of tree spacing and organic manure on number of fruits per plant of Capsicum annuum under Melia composita based Agroforestry system. Among three spacing maximum number of fruits was recorded in capsicum plants grown as sole crop ‘S0’. Among different doses of organic manures, maximum number of fruits per plant was recorded with the application of vermicompost @ 3.5 kg /plot which was statistically at par with 7 kg FYM /plot.

OKRA

Palade *et al*. (1992) conducted a trial to see the effect of alley cropping with subabul and fertilizer application on yield of okra. Plant height, fruit weight, number of fruit and fruit yield found, maximum in alley cropping along with fertilizer. Yield also did not differ among the alley cropped with and without fertilizer treatments and the control treatment with fertilizer.

Chandraker and Prajapati (2017) revealed that plant height, number of leaves, collar diameter, number of capsule per plant, number of seed per capsule, seed test weight, seed yield and oil yield were recorded maximum in 100% vermicompost.

PEA

Bhutia (2013) studied effect of different doses of inorganic fertilizers + RIS on growth and yield attributes of pea under peach based agroforestry system and found that maximum plant height, number of pod per plant, pod length, pod breadth and pod weight in the treatment T1, 100% recommended NPK (25 kg ha-1 N, 60 kg ha-1 P2O5 and 60 kg ha-1 K2O) with rhizobium treated seed.

Bhatt (2015) performed an experiment to see the effect of tree spacing and organic manure on number of pods per plant of Pisum sativum under Melia composita based agroforestry system. Among various treatments of organic manure, maximum number of pods per plant were recorded with the application of vermicompost @ 3.5 kg /plot which was statistically at par with 7 kg FYM /plot and 2.5 kg vermicompost /plot.

Gonmei *et al*. (2018) from their study concluded that the organic manure FYM had mark the influence on the growth and yield parameters like plant height, number of pods per plant, number of peas per pod and pod yield (q/ha). The FYM found out to the most effective than the other treatments in pea under Jatropha curcus based agroforestry system.

TOMATO

Bhatt (2015) performed an experiment to see the effect of tree spacing and organic manure on number of fruits per plant of Solanum lycopersicum under Melia composita based agroforestry system. In the interaction of treatment with spacing, T6S0 gave significantly maximum number of fruits per plant. Among different doses of organic manures, maximum number of fruits per plant was recorded with the application of vermicompost @ 3.5 kg /plot which was followed by 7 kg FYM /plot.

Anjali *et al*. (2017) performed an experiment using different level of organic and inorganic fertilizers combination viz., T0 (control), T1 (100% NPK), T2 (100% FYM), T3 (75% NPK + 25% FYM), T4 (50% NPK + 50% FYM), and T5 (25% NPK+ 75% FYM) for tomato plants under poplar based agroforestry system. The highest plant height, the maximum number of branches, number of flowers and fruits/plant were obtained best in T2 (100% NPK) application of the recommended dose of nutrients.

Palade *et al*. (1992) conducted a trial to see the effect of alley cropping with subabul and fertilizer application on yield of tomato. The number of fruits, fruit size and yield was recorded highest in the alley cropping with the application of fertilizer. Alley cropping resulted in increase in fruit sizes similar to those in fertilized control plots.

Olasantan (2000) concluded that the application of 30 kg N/ha significantly increased the number of fruits/plant, fruit weight, fruit yield (g/plant and t/ha) of tomato under hedgerow pruning applied as mulch in Gliricidia based alley cropping system.

GARLIC

Umrao et al. (2013) studied having treatment combinations control, FYM, vermicompost, neem cake, 50% FYM + 50% vermicompost, 50% FYM + 50% neem cake, 50% vermicompost + 50% neem cake. The results showed that different treatment of organic fertilizers had a positive effect on the growth and yield of plants under teak based agroforestry system. Among

all the treatment combinations, the application of FYM have better influence on growth and yield of garlic under shade of teak as compared to open condition.

SWEET POTATO

Panwar and Wani (2014) revealed that Nitrogen, Potash, and Phosphorus was applied in the form of organic manure such as farm yard manure, vermicompost, and neem cake in a sweet potato variety known as pusa red under poplar based agroforestry system. The results showed that an application of vermicompost recorded highest length of vine, number of branches/vine, shoot fresh weight, shoot dry weight, tuber yield/plot, number of tubers per plot under poplar trees.

Conclusion

Combined application of organic manure (FYM, neem cake, mahua cake, vermicompost and poultry manure) with inorganic fertilizer can increase yield of vegetable crop under agro-forestry system. Application of biofertililzer can also provide higher yield in case of vegetable crops. Also we can improve growth and yield of vegetable by incorporating it in Gliricidia and Leucaena based alley cropping system.

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Seminar No. 4

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PRODUCTIVITY STATUS OF COMMERCIAL PLANTATIONS IN INDIA

Introduction

The global timber market is the largest industrial segment and the annual sales of India are 8.733 billion dollar. India is among the world largest economic growing at more than 7 percent GDP since 2003 and the country recognizes the need for high growth rate in order to improve quality of life. The unsustainable extraction and illegal trade in timber has resulted in loss of forests and growing stocks in many countries. Presently the world forests are depleting at the rate of 16 million ha per annum (Manoharan, 2011). The productivity of forests is extremely low as 0.7 cum/ha/year as against the world average 2.1 cum/ha./year. The average growing stock is 32 cum per ha as compared to world average of 110 cum per ha. The per capita forest area in the country is 0.08 ha as compared to the world average of 0.64 ha (Malik and Dhanda, 2018).

Forest productivity defines in terms of traditional forest products where productivity is measured as the annual average change in cubic feet, board feet, cords, or biomass of wood. Losses in volume to tree mortality and harvesting are also measured and subtracted from growth to provide net growth.

Brief review of research studies

Patil *et al.* (2017) reported significant difference in productivity among different planting densities of *Melia dubia* and maximum productivity was recorded in planting density of 2500 trees/ha (125.00 m^3/ha, 148.33 m^3/ha, 165.83 m^3/ha and 189.25 m^3/ha, respectively at 42, 45, 48 and 51 MAP) which was statistically at par with planting density of 1666 tree/ha, 1000 tree/ha and 833 tree/ha.

Lodhiyal and Lodhiyal (2003) studied the biomass and net primary productivity (NPP) in 5, 10 and 15 years old Shisham (*Dalbergia sissoo* Roxb.) forest planted after clear cutting of Sal (*Shorea robusta*) mixed broad leaved tree species in Bhabar adjacent to foothills in Kumaun of central Himalaya. The tree density was 625 trees ha^{-1} for each forest. The above ground biomass and NPP of trees increased with increase in forest age. The total vegetation biomass and NPP ranged from 35.1 (5 years) to 89.8 t ha^{-1} (15 years) and 11.4 (5 years) to 14.8 t ha^{-1} per year (15 years), respectively.

Shahapurmath *et al.* (2017) stated that the growth of teak tree grown in farmland was significantly higher than tree grown in pure plantation. For instance, tree volume (0.618 m^3) and timber volume (0.335 m^3) was higher in farmland than trees grown in pure plantation. There was a strong influence of age on growth of teak trees grown in both farmland and pure plantation. For

instance, tree volume (1.093 m^3) and timber volume (0.552 m^3) of higher age class (A4: 21-25 years) was maximum as compared lower age class (A1: 5-10 years) with values of 0.193 m^3 and 0.081 m^3, respectively.

Puri *et al.* (2002) evaluated five clones (G3, G48, 65/ 27, D121 and S7C1) of Poplar for NPP which was planted in an agrisilviculture system at spacing of 4 x 4 m with soybean grown as an intercrop. After 4 years they found non significant differences in stem wood, branch, leaf, bark, root, litter and total NPP. However, maximum total NPP was reported in clone 65/27 (15.51 Mg/ha/year).

Sukanya (2011) studied comparative biomass production of *Ailanthus triphysa* at different stand ages and management regimes and found maximum total biomass (384.67 Mg/ha) and MAI (17.48 m^3/ha/year) in 22 years old woodlots of *Ailanthus triphysa* as compared to other land use system. She also studied comparative biomass production of MPT's at different stand ages and management regimes and found maximum MAI (39.10 m^3/ha/year) in 8.8 years old woodlots of *Acacia auriculiformis*

Agrawal and Saxena (2017) evaluated the productivity of pulpwood plantations of FDCs and they found that the productivity of pulpwood plantations of FCDs ranged from 4.76 cum/ha/year to 22.95 cum/ha/year. The introduction of clonal varieties of these species had improved the productivity of FDC's pulpwood plantations. In terms of production per hectare by FDCs raising eucalyptus plantations, Andhra Pradesh FDC has achieved the highest figure of 11.69 cum/ha/year. As well as the FDC of Karnataka and Kerala has achieved the productivity of *Acacia* 22.95 and 18.99 cum/ha/year respectively. They also reported the average productivity of commercial plantation of different state is 0.77 cum/ha/year. FDC of Tamilnadu, Kerala and Karnataka had achieved the overall productivity 4.39, 4.03 and 3.66 cum/ha/year, respectively.

Palanisamy *et al.* (2009) studied the productivity of teak i.e. the total yield and mean annual increment (MAI) in different age and site qualities in all India yield and standard volume table. The dry teak plantations of Madhya Pradesh have 80 years rotation, 50 to 60 years in Kerala and 40 years for plantations of Maharashtra Forest Development Corporation. The productivity (MAI) ranges from 11.27 to 2.03 cum/ha/year with different age and site qualities. The yield ranges from 588.47 to 131.90 with different age and site qualities.

Agrawal *et al.* (2017) studied year wise plantation area and wood production in Gujarat and Maharashtra by J. K. Paper Limited. The data represent the highest plantation and production in year 2015-16 followed by 2016-2017. J. K. Paper Limited covered about 50000 ha of agro and farm forestry plantations. This will helps to increase the depleting forest cover by planting fast growing high yielding clones with 30-50 MT/ha/year productivity which is 4-5 times higher than ordinary seedlings plantation.

Luna *et al.* (2011) evaluated height, diameter growth and volume production of 12 clones of poplar at Kharkan Research Station, Hoshiarpur (Punjab) at the age of 3 years. The clone WSL - 39 achieved the best growth and maximum volume, attaining diameter of 14.74 cm; height 14.42 m and volume 0.1040 m^3/tree. The volume production of clone Udai was at par with WSL – 39 at 2 and 3 years of age. On the basis of present results, WSL-39 and Udai clones

can be included for plantation to broaden the genetic base and more importantly for productivity enhancement.

Singh and Toky (1995) studied net primary productivity in *Leucaena leucocephala*, *Acacia nilotica* and *Eucalyptus teriticornis* and they found higher net primary productivity in 4 years old plantations (15.70, 29.19, 32.62 ton ha^{-1} $year^{-1}$) as compared to 8 years old plantations (14.14, 21.02, 24.71 ton ha^{-1} $year^{-1}$) of *Leucaena leucocephala*, *Acacia nilotica* and *Eucalyptus teriticornis.*

Prasad *et al.* (2011) studied dry bole biomass production in Leucaena (kg/tree) as influenced by various spacing as per different diameter classes at 51 MAP and reported highest biomass with spacings of 3 x 2 m (78.7 kg/tree) which was followed by spacings of 3 x 1 m (75.1 kg/tree).

Luna *et al.* (2009) evaluated various clones of Eucalyptus and found that clone no 288 which was planted at 3.8 x 3.8 m reported maximum DBH (16.50 cm), Height (22.73 m), MAI O ($0.071m^3$/tree), MAI U ($0.057m^3$/ tree), MAI O (48.79 m^3/ha.) and MAI U ($39.79m^3$/ha.)

Conclusion

Forest productivity is a critical criterion of sustainability for plantation forests because of its important relationship with economics and profitability. Site quality plays a significant role in productivity and that can be override by management practices *viz.*, mechanical site preparation, fertilizer application, and the adoption of faster growing genotypes. Productivity of commercial plantations can be increased by planting fast growing tree species *viz.*, *Melia Dubia*, *Populus deltoides*, *Ailanthus triphysa*, Eucalyptus clones, *Leucaena leucocephala*, *Gmelina arborea* and *Acacia auriculiformis*.

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Seminar No. 5

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NURSERY TECHNIQUES FOR QUALITY SEEDLINGS PRODUCTION IN SWIETENIA

Introduction

Swietenia is genus of family Meliaceae, having two major species: *Swietenia macrophylla* and *Swietenia mahagoni*. Mahogany produces two valuable commodities: extremely beautiful wood and seeds. Both species of *Sweitenia* are popularly cultivated for its timber. The wood of mahogany combines rare qualities *viz.,* beautiful color, light in weight and resistance to rot. *S. macrophylla*, exotic to India also known as large leaved mahogany which is evergreen in nature. It is extensively cultivated as an ornamental tree in West Bengal, Orissa, Bihar, Maharashtra and Karnataka. On the other hand, *S. mahagoni*, commonly known as small leaved mahogany is exotic to India and deciduous in nature. Natural regeneration of tree species is a long term process. However, nursery plays important role in artificial regeneration. With various benefits, nursery techniques can be classified into major three groups: seed; nursery development and activities; nursery pest and diseases (Kumar, 1999).

Review of literature

Seed

Mansor *et al.* (1997) demonstrated collection and handling of *Swietenia macrophylla* seeds. Results showed that large size fruits weighing (482.2 g) produced seeds with higher speed of germination compared to seeds from medium and small sized fruits. However, small sized fruits were found to produce maximum filled seeds (87.50%) compared to medium and big sized fruits.

Marzalina and Normah (2001) in their desiccation study showed that when seeds of *S. macrophylla* with intact testa kept in silica gel, showed faster and higher rate of moisture

reduction up to 2% whereas in circulated air oven reduced moisture much faster up to 35-9% within first two days.While desiccation in ambient temperature and cold room caused seed moisture content to decline at slower rate. Desiccation of seed without testa using oven drying method caused almost total loss of moisture. However when kept at ambient temperature and cold room, it maintained moisture content up to 5%.

Nursery and its activities

Kumar *et al.* (2015) undertook an experiment of pre-sowing treatment of *S. macrophylla* seeds and observed that the highest germination percentage (82.33%), maximum mean daily germination (2.29), peak value of germination (2.77) and vigour index (6274.37) were observed for the seeds treated with 100 ppm benzyl adenine (BA) for 12 hrs. Further, for growth and biomass attributes maximum collar diameter (4.96 mm), tap root length (42.24 cm), root biomass (2.24 g), shoot biomass (2.30 g), biovolume (414.95) and quality index (0.43) were found in seed treated with 1% potassium nitrate (KNO_3) for 12 hrs. Moreover, shoot length (42.24 cm) was found maximum in water soaking for 24 hrs.

Fitzpatrick (1985) illustrated the feasibility of using urban waste products for the container production of *S. mahagoni*. The results showed that seedlings grown in media horticulture mix (cypress shaving, perlite, Canadian peat, Florida peat and sand (3:3:2:2:1) along with eventual application of supplemental nutrition using Osmocote (N-P-K; 18-2.6-10) and Micromax (contains micronutrients) and irrigated with tap water showed significantly higher growth index (401) at 17 months.

Fitzpatrick *et al.* (1994) studied effect of repotting media on growth of *S. mahagoni* seedlings and found that height (60.7 inches) as well as collar diameter (1.26 inch) of seedlings grown in the standard black plastic container (SBPC) with 100% screened medium was maximum compared to other treatments including control. Also, higher shoot dry weight (612 g) was recorded with 30/60/10 medium in air root pruning container (ARPC), significantly maximum root dry weight (267.1 g) was found in 30/60/10 medium in standard black plastic container (SBPC). However, seedling grown in air root pruning container (ARPC) with 100% screened medium showed higher average shoot: root ratio (3.121) than seedlings grown in the standard black plastic container (SBPC).

Woods *et al.* (1998) experienced zero mortality in the *S. macrophylla* seedlings grown in Brewer's waste/saw dust and fertilized with 4 g and 20 g Nutricote. However, maximum height was observed in control, which is comparable with coir+ 4 and BW + 4 treatments.

Svenson *et al.* (1995) in their experiment showed that *S. mahagoni* had higher height growth rate (4.5 mm/ day) and higher shoot: root ratio (2.7) when grown in $Cu(OH)_2$ treated container rather than non-treated container.

Mansor *et al.* (1997) found maximum germination energy (96.7%) at 18 days and germination value (22.39) from large size fruit as compared to medium and small sized fruit of *S. macrophylla*.

Marzalina and Normah (2001) in their experiment showed that cold room desiccated seeds of *S. macrophylla* with intact testa gave higher germination rate. In case of seeds with testa

removed, highest germination was recorded when seeds were desiccated at ambient temperature followed by cold room desiccation.

Morris *et al.* (2000) showed that germination of *S. macrophylla* increased linearly with increasing shade. Mean maximum germination (84%) was recorded in high level of shade (80%) when seeds were sown in irrigated condition in April.

Rizana and Jayanthi (2001) demonstrated effect of shade on seedling growth of *S. macrophylla* and found no significant difference in height increment and specific leaf area in shade and control treatments. However, mean internodal length of seedlings were greater in low shade treatment than under high shade.

Hossain (2012) compared growth performances of seedlings grown in two different media and found that maximum plant height and collar diameter of *S. mahagoni* seedlings were higher in natural forest soil.

Suriyanarayanan *et al.* (2012) assessed the effect of paper mill effluent and sludge on seedling growth of *S. macrophylla* and found that there was a significant difference in plant growth among the treatments. Treated effluent applied to seedling recorded the maximum plant height (61.83 cm), stem diameter (1.4 cm), stem dry weight (19.67 g), leaf dry weight (12 g), root dry weight (6 g) and shoot to root ratio (0.31) when compared to all other treatments.

Amira and Asharaf (2013) in their experiment demonstrated that significantly superior seedling growth of *S. mahagoni* was recorded when plants were treated with NPK mineralized fertilizer. However, seedlings irrigated with Intensive Biofloc Tilapia Culture Effluent (I-BFT-TCE) showed a comparable growth, among all other fish effluents. This suggests that I-BFT-TCE can be used as an efficient alternative effluent to the mineral NPK form. Moreover, irrigation with fish effluents increased the total macro-nutrients content of N, P and K of leaves as compared to control.

Vidyasagaran *et al.* (2014) undertook an experiment of production of *S. macrophylla* seedlings using municipal garbage and found that treatment T_7 [Soil: partially decayed tea waste: sand (1:1:1)] recorded the maximum height (48 cm) and girth (7.5 mm). In the case of number of lateral roots (22), highest value was observed in T_2 [Soil: partially decayed municipal waste (1:1)]. Maximum length of tap root (95.42 cm), number of leaves (19.38) and maximum chlorophyll content(44.23 mg/g) were found in T_5 [Soil: partially decayed municipal waste: sand (1:1:1)] whereas highest quality index (1.40) was found in treatment T_1[Soil : sand: cow dung (1:1:1 ratio - control treatment)]. Furthermore, nutrient content of the seedlings for different treatments indicted that the highest N content(0.77%) was recorded in treatment T_7; treatment T_2 showed maximum concentration of phosphorus (0.47%) whereas maximum concentration of potassium (0.76%) was recorded in T_4 [Soil: partially decayed tea waste (1:1)].

Sarhaan *et al.* (2015) showed that treatment of clay and microbien at concentration of 20 ml increased seedling height (140.8 cm) of *S. mahagoni.* Maximum number of leaves (55.67) were recorded in clay media and application of microbien 20 ml which was at par with treatment sand+ clay+ microbien 20 ml. However higher stem diameter (1.5 cm) and maximum leaf area (137.67 cm^2) were recorded in sand+ clay+ microbien 20 ml treatment.

Begum *et al.* (2018) undertook an experiment of different containers for seedling raising and found that *Swietenia macrophylla* seedlings raised in poly bag achieved maximum shoot length (25.4 cm) and collar diameter (4.8 cm) compared to root trainers. Root length (18.2 cm) was higher in root trainers than polybags. In case of fresh and dry biomass production, seedlings raised in polybag showed better production.

Patel and Suresh (2018) studied the combination effect of media, inorganic fertilizers and biofertilizer on biometric parameters of *S. macrophylla* and revealed that maximum growth in context to shoot length (53.47 cm), root length (39.71 cm), collar diameter (3.63 mm), number of leaflets (27.1)and other quality parameters such as volume index (7.03 cm^3), sturdiness quotient (14.75) and quality index (0.26) were recorded when 50 g vermicompost + 5 g azophos + 1 g of NPK/seedling applied in the media of soil: FYM (3:1).

Hossain *et al.* (2004) studied efficacy of different IBA concentration on rooting ability of *S. macrophylla* and *Chukrasia velutina* cuttings and found that maximum rooting as well as root dry weight were recorded when cuttings were treated with 0.4% IBA.

Protection measure

Liju *et al.* (2014) demonstrated control of anthracnose in *S.macrophylla* using biocontrol agents. Plants inoculated with *Tricoderma viride* and the chemical fungicide (Carbendazium) had significantly reduced the disease severity compared to negative control (inoculated/untreated checks). Moreover, treatment of *T. viride* showed recovery as well as emergence of new leaves in diseased seedlings.

Conclusion

Study concluded that Swietenia is one of the prominent commercial species and for production of quality seedlings in large scale in forest nursery following conclusions to be considered, Seed grading shows that medium to large sized seeds resulted in better germination over smaller seeds. The general germination of Swietenia is 50 to 60 per cent. However, pre-sowing treatments may enhance seed germination. For instance, seeds treated with 100 ppm benzyl adenine for 12 hrs increased germination upto 33 % as compared to seeds without pre-treatment. Plants can be produced by means of vegetative propagation, where stem cuttings treated with 0.2- 0.4 per cent IBA resulted in 80 per cent success. Several study showed that seedling growth can be enhanced by using proper potting media. Example media with coco mass and soil in polybags produced higher growth. Similarly, vigorous seedlings can be grown using application of biofertilizers and inorganic fertilizers (50 g vermicompost + 5 g azophos + 1 g of NPK/seedling in soil and FYM mixture of 3:1). Similarly effluents (sewage or fish culture) may also be used to obtain higher growth and biomass production in Swietenia at nursery. Review shows that there is no major insect pest incidence in seedling stage; however, shoot borer and sapling borer recorded as minor pest and they may be managed by providing proper light. Anthracnose disease has been noticed and it can be reduced by using bioagent, *Tricoderma viride* in the nursery stage.

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Seminar No. 6

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CRITERIA AND INDICATORS FOR SUSTAINABLE FOREST MANAGEMENT

Introduction

Sustainable forest management has been considered as an integral component of sustainable development since the UNCED Conference at Rio de Janeiro in 1992, also called the Earth Summit. After the summit (UN, 1992), the notion of sustainable forest management

rapidly gained interest. At the same time the International Forest Principles were formulated for the first time by the world leaders and the first global policy on sustainable forest management (SFM) was adopted. Of course, in the present situation, there is a necessity to have monitoring, assessment and reporting system of forest resources at every level including local, state and national level. Criteria and Indicator (C&I) approach ensures the sustainable forest management with the involvement of the all stakeholders. The purpose of C&I is to provide a tool for monitoring, assessing and reporting changes and trends in forest condition and management system at National as well as at FMU level. It also provides a means of assessing the progress towards SFM.

'Criteria' is defined as aspect or essential factor of forest management whereby sustainable forest management can be assessed. Each criterion is accompanied by set of related indicators (qualitative, quantitative or descriptive) and describes s state or situation, which should be met to comply with sustainable forest management. Whereas, an 'Indicators' addresses the quantitative, qualitative or descriptive attribute that when measured or monitored periodically indicates the direction of change within the criterion. There are nine major regional/ International processes initiated on C&I for SFM worldwide. The FAO/ITTO expert consultation on C&I for SFM recognized seven fundamental elements / criteria for SFM that are important for facilitating international communication on forest related issues. Forest Research Institute (FRI), Dehradun evolved and finalized the National set of indicators for India, which consists of 8 Criteria and 37 indicators. The overall global and Indian initiatives on C&I for SFM is described below using case studies.

Breif review of Literature

Global Initiatives towards Development of Criteria an Indicators for Sustainable Forest **Management**

FAO/ITTO (1995) an expert consultation on C&I for SFM had identified seven fundamental elements / criteria for assessing SFM.

Castaneda (2000) had compiled the nine major international processes on C&I for SFM.

FAO (2000) had studied the international process on C&I for SFM and came up with more information like region and type of forest covered by each process.

Linser et al. (2018) had reviewed 25 years C&I for SFM at world level, found that their were 9 major international processes having total 89 criteria and 579 indicators worldwide.

Anon. (2007) observed 30 criteria along with 205 indicators worldwide and divided the C&I as per the ecological, economic and socio-cultural parameters.

ITTO working out C&I for SFM continuously and during 1992, they had identified 7 Criteria and 66 indicators (ITTO, 1992), whereas in 2005, total 7 criteria and 57 indicators had been revised (ITTO, 2005). Later in 2016, 7 criteria and 58 indicators were finalized for SFM (ITTO, 2016).

ITTO (2016) categorized the applicability for tropical forest into three categories namely, fully applicable, partially applicable and not applicable. They had also observed the applicability at landscape level apart from national level and FMU level indicators.

Anon. (1999a) they identified 7 criteria and 47 indicators in general under the Dry zone Africa process for African countries and 7 criteria and 48 indicators for SADC African countries.

Anon. (1999b) identified 7 criteria and 49 indicators under the Dry zone Africa process for CILSS African countries.

MCPFE (1995 and 2000) identified 24 criteria and 104 indicators for SFM under Pan European Forest process for Boreal, temperate and Mediterrian type of forest at regional and national level.

FAO (2001) had identified 7 criteria and 67 indicators for SFM for temperate and boreal forest under Montreal process.

ACT (1995) initiated Tarapoto proposal and they came up with 1 criterion with 7 indicators at global level, whereas 7 criteria with 47 indicators at national level and 4 criteria and 22 indicators at FMU level for Amazon forest.

FAO (1999) identified 7 criteria and 65 indicators for SFM at regional and national level under Near East process.

Anon. (1997) initiated Lepaterique process for Central America forest and identified 4 criteria and 40 indicators at regional level, 8 criteria and 53 indicators at national level and 5 criteria and 50 indicators at FMU level. Total 8 countries have taken part.

ATO/ITTO (2003) initiated ATO process on C&I for SFM for ATO member countries. They have came up with 28 criteria and 60 indicators at regional and national level.

Anon. (1999c) initiated Bhopal India process for regional initiatives for development of national level C&I for sustainable management of Dry forest in Asia. They identified 8 criteria and 49 indicators at national level for Dry forest in Asia.

Garcia and Diez (2014) found that the main difference concerns criteria 7 of Montreal process, the concept to of which was similar to criteria 1 of ITTO process.

Jalilova *et al*. (2012) had identified 7 criteria and 49 indicators for assessing sustainability of Kyrgyzstan forest.

Islam *et al*. (2010) identified 7 criteria and 64 indicators for SFM in Malaysia. Further, they had identified 7 criteria and 56 indicators along with 171 activities and 150 standards of performance for assessing SFM at the FMU level.

FAO (2010) formulated 4 principles, 17 criteria and 57 indicators for wood fuel, while 4 principles, 16 criteria and 32 indicators for charcoal production to ensure sustainability.

Ozturk *et al*. (2013) had formulated 4 criteria, 11 sub-criteria for tourism in general and 12 sub criteria for ecotourism and 11 indicators to asses and ensure sustainability.

Indian Initiatives towards Development of Criteria Indicators for Sustainable Forest Management

FRI (2009) evolved the national set of C&I for SFM for India. They finalized 8 criteria and 37 indicators for SFM in India at national level.

Kotwal *et al*. (2007) observed that Out of 37 indicators, 20 indicators whose data were readily available in office records, while 11 indicators need some efforts to generate data and 6

indicators needs detail research to generate data. Further, regarding applicability, they observed that out of 37 indicators, 31 applicable at national level and 37 applicable at FMU level.

Kotwal *et al*. (2008) had identified 8 criteria and 39 indicators for sustainable management of Tree Outside Forest.

Anon. (2008) identified 8 criteria and 30 indicators to ensure the sustainability at FMU level for Ghumsur North Forest Division.

Dasgupta (2004) observed that Criteria 1 (a) and 2 relatively performing well than others. Whereas, sustainability value 55.8 implies that the overall status of sustainability of forest resources in India may be classified mildly as towards sustainability.

Kotwal *et al*. (2004) observed that out of 11 indicators only 4 indicators were ensuring sustainability in Jhabua forest division, while rest 7 indicators are un sustainable status.

Anon. (2004) worked out set of C&I for assessing sustainability of Sheopuri Forest Division. They had identified 8 criteria and 20 indicators at FMU level. The result showed that 1, 2 and 7 ensuring complete sustainability.

Smriti Kumari *et al*. (2006) investigated C&I for sustainable ecotourism of Kanchanzonga Biosphere Reserve of West Sikkim. They had identified 8 criteria and 58 indicators for sustainable management of ecotourism in KBR.

Bhattacharya and Smriti Kumari (2004) explored the development of C&I for Sustainable ecotourism management and they did come up with 7 criteria and 60 indicators for sustainable ecotourism in KBR of west Sikkim.

Omprakash *et al*. (2009) carried out study on development of C&I for sustainable NTFP management with respect to tendu leaves at FMU level for South Seoni Forest Division, MP. They had formulated 3 principles, 11 criteria and 32 indicators for sustainable NTFP management for tendu leaves.

Deshmukh *et al*. (2016a) had identified 8 criteria and 40 indicators for sustainable management of agroforestry in Akola district.

Deshmukh *et al*. (2016b) identified 8 criteria and 60 indicators for sustainable management of ecotourism in forests of Akola district.

The criteria and indicators give an opportunity to monitor and assess the state of sustainable forest management. For application and monitoring of criteria and indicators by the communities, it is imperative that we take care of the institutionalization and capacity-building needs of the communities. At Global level, nine major international processes on C&I for SFM have been recognized worldwide. FAO/ITTO expert consultation on C&I for SFM have identified seven fundamental elements/ criteria for assessing SFM and facilitating international communication on forest related issues. In total 89 criteria and 579 indicators have been identified worldwide for assessing sustainability under 9 international process. Such efforts need to be workout at FMU level in other areas like NTFP, Ecotourism, bio-fuels, Agroforestry etc. to manage the forest resources sustainably.

Government of India constituted a National Task Force in November, 1999 which had identified 8 Criteria and 51 indicators of B-I Process. This set was again refined in year

2000 and 8 Criteria and 43 indicators were identified. Forest Research Institute, Dehradun evolved and finalized the National set of indicators for India, which consists of 8 Criteria and 37 indicators. The scientist foresters and other stakeholders are working on develop C&I for sustainable management of multiple use forest resources. There is need to work on the coping mechanism for climate changes through C&I for SFM interventions. The MoEF, GOI has opened SFM as well as Forest certification cell which needs to be strengthen. All efforts made by the Bhopal-India process in support with FRI, Dehradun have been fulfilled by including C&I framework in Working Plan code, 2014. This may help to take the C&I for SFM in mainstreams of the SFM and help to achieve the international commitments towards SFM.

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Seminar No. 7

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ROLE OF SACRED GROOVES IN BIODIVERSITY CONSERVATION

Introduction

The word sacred means: considered to be holy or 'connected with a god' and the word 'groove' means: a small area of land with trees of particular types grown on it. Conservation of biodiversity is an environmental philosophy of sacred grooves. In India, the practice of worshipping established dates back to 3000 B.C. to 5000 B.C. People learnt to cultivate plants and domesticate animals, about 10,000 years ago. Shifting cultivation could be one of the reasons for creation of sacred grooves. Its might have also originated as result of its utilitarian nature and social institution or as a part of the taboo that evolved historically over several generation to provide a site for culturally crucial social interactions (Gadgil and Vartak, 1976; Hazra, 1980 and Kalam, 1995). Sacred grooves represent an ancient Indian conservation tradition, protected by lot of Reverence, Respect, Fear and Sentiments. Broad classification of Sacred grooves on the basis of number of sacred trees, nature of human interference and structural frame/ land-use/religion (Tiwari et al., 1998). In India, Prior to 2002 these forest regions were not recognized under any of the existing laws. But in 2002 an amendment was brought in Wildlife Protection Act, 1972 to include sacred grooves under the act. The total number of sacred grooves reported 13,720 so far which consists an area of about 39,063 ha. 0.055% of the total forest area of India (Lalitha, 2015). Of which, 42; 2820 and 1424 Number of Sacred groove were reported in Gujarat, Maharashtra and Karnataka, respectively. Biodiversity incorporates the preservation, maintenance, sustainable use (conservation), recovery and enhancement of the components of biological diversity. Moreover conservation - is the sustainable use of resources and encompasses protection as well as exploitation. India is one of the 17 mega diverse countries, which contains four biodiversity hotspots. It has around 8% of all mammals, 13% of birds, 8% of reptiles, 6% of amphibians and 6% of all plant species population. Sacred grooves are playing importance role in conservation of Biodiversity through the conservation of medicinal, threatened, endangered, rare and endemic species flora and fauna.

Brief review on case study of Sacred grooves:

Prasad and Raveendran (2012) reported 81 IUCN status of endemic plant diversity in selected sacred grooves of Kasaragod, Kerala. Of which 23 qualify for RET categories. Out of 23 RET plants 15 are highly traded for medicinal purposes. Moreover, the percentage of medicinal plants in these groves varies from a minimum of 65% in Paramel Kavu to a maximum of 85% in Kayyur. The maximum percentage of endemic plants was 19% in both Kamma dam and Paramel Kavu.

Maru and Patel (2013) documented 37 plant species belonging to 26 families in six sacred groves of Jhalod and surrounding areas in Dahod District, Gujarat. They found maximum (34) plant species in Kedarnath Mahadev sacred grove. Furthermore, Sterculia urens, Terminalia bellerica and Ailanthus excelsa were reported only in one sacred grove.

Rawat (2014) observed the phytosociological parameters of the study sites and revealed that tree, shrub and herb species were more in number at temple forest site than the control site. Further, the relative humidity values of both at morning and evening hours were also high in temple forest site as compared to control site.

Panda *et al*. (2014) recorded 16 plant species of IUCN categories present in the sacred groves of Koraput. Furthermore, plant species Pterocarpus santalinus came under endangered category and 3 species of plants Shorea robusta, Buchanania lanzan and Woodfordia fruticosa came under low risk and whereas 6 species were under least concern category. Moreover, most of the sacred species came under the Caesalpiniaceae family followed by Asteraceae and Combretaceae.

Basu (2009) stated that the Shorea robusta, Butea monosperma and Madhuca longifolia trees were dominant species in sacred groves of the district of Bankura of West Bengal. However, Shorea robusta reported maximum number of individual tree in sacred grove as compared to remaining tree species. Furthermore, the IVI indicated an overall dominance by Shorea robusta with IVI value of 38.94.

Ghildiyal *et al*. (2008) reported 372 taxa of phanerogams and cryptogams in Tarkeshwar sacred grooves in Garhwal Himalayas. Among these taxa, 314 were angiosperms, 4 gymnosperms, 16 pteridophytes, 15 bryophytes and 23 fungal species.

Das and Menon (2011) recorded 197 taxa, comprising 165 genera and 74 families in Eringole sacred groove of Kerala. Among them, 8 families, 22 genera and 28 species were monocotyledons and the remaining 160 species and 7 intra species came under 141 genera and 64 families were dicotyledons. Further, among the 197 taxa, 12 taxa belonging to RET category.

Bhakat et al. (2008) recorded 80 species angiosperms covering 42, 10, 16, and 12 species of herbs, shrubs, trees and climbers, respectively in Sitabala sacred groove of Midnapore District.

Prasad and Bharathi (2016) investigated species richness, indices and density values of the five sacred grooves of Virajpet, Karnataka and found a total of 132 tree species belonging to 113 genera and 45 families were identified within five sacred groves which has represented higher average basal area (51.73-85.65 m2 ha-1) and tree density (453.33-515.9 individuals/ha) as compared to other forests of Western Ghats region.

Hangarge *et al*. (2016) conducted comparative study between the floristic composition of sacred groves and its surrounding areas and recorded a total of 151 plant species belonging to 54 trees, climbers 33, shrubs 12 and herbs 53 in four sacred groves. They concluded that the sacred grooves consists more diverse and unique plant species as compared to its surrounding areas.

Jamir and Pandey (2003) studied diversity of vascular plants in three sacred groves of the Jaintia Hills, in northeast, India and observed maximum 334 species, 209 genera, and 97 families comprising pteridophytes, gymnosperms and angiosperms diversity in Urkhla sacred groves as compared to other sacred groves. They concluded that favorable climatic conditions and prolonged protection have contributed to the high species richness of the groves.

Rampilla *et al*. (2015) carried out a study on floristic diversity and phyto-sociology of the Indrakiladri sacred grove, Krishna district, Andhra Pradesh, India, and found the total number of species encountered in four sides was 115, 72, 55, and 59 in east, west, north and south side, respectively. Further, they found higher diversity in inside sacred groves as compared to outside of the sacred groves.

Subramanian *et al*. (2018) examined the woody species diversity of Melkalpoondi sacred grove in Tittakudi Taluk of Cuddalore district, Tamil Nadu and recorded about 46 woody plant species representing 40 genera and 29 families of which 30 species were trees and 16 species were lianas.

Rawat and Dookia (2017) investigated diversity of mammals of a sacred groove in Kolu Pabuji Oran of western Rajasthan and recorded 32 different mammals species belongs to 11 families.

Mohanta *et al*. (2012) studied faunal diversity in various sacred grooves of the Balasore wildlife division. They found 15 faunal species. In case of birds highest frequency was noticed in common myna (53.8%). However incase of mammals, highest frequency was recorded in common garden lizards (69.2 %).

Patel and Patel (2013) recorded about 43 different plant species in the 7 sacred groves surveyed in Banaskantha District, Gujarat, India. Out of 43 plant species, 47% are trees, 16% shrubs, 30% herbs and 7% climbers.

Ghalme and Deokule (2014) conducted a study on conservation of ethno-medicinal plants in sacred grooves of Dapoli tahsil of Ratnagiri District and recorded a total of 48 species from 42 genera and 27 families. Among them 11 were threatened and 12 endimic.

Vandana *et al*. (2012) studied sacred grooves as ethno botanical gene pools in tribal area of the western Himalaya and found a total of 96 plant species from 41 families and 77 genera. Among the observed plants 86 were angiosperm, 10 gymnosperm and as per IUCN standards 6 were critically endangered, 15 were endangered and 17 were vulnerable. Furthermore, 66 species had medicinal importance while 16 species were used for religious purpose.

Sivalingam *et al.* (2016) recorded 6 important IUCN category ethno medicinal plants like Aegle marmelos, Excoecaria agallocha, Ficus religiosa, Prosopis cineraria, Pterocarpus marsupium and Stereospermum suaveolens in Cuddalore District.

Kulkarni *et al*. (2018) reported total 296 species out of these, 45 species were found endemic. Out of 15 sacred groves surveyed, highest number of plant species (64) was noted in Dhuprahat Sacred groves. Moreover, highest endemic plants (12) were registered in Durgavadi Sacred groves.

Sen (2018) observed 32 tree species belonging to 30 genera distributed in 23 families from 13 orders in Joypur Joysini Matar Than sacred grove of West Midnapore district. The *Ficus benghalensis*, belongs to family Moraceae showed the highest SIVI (34.58%). Further, majority of tree species exhibited good regeneration followed by poor regeneration and fair regeneration, respectively.

Tripathi (2004) observed more number of species of wood rotting fungi (56) and host species (37) in the Undisturbed (Mawphlang) as compared to disturbed (Nongkrem) sacred groves of Meghalaya.

Gaude and Janarthanam (2015) reported Nymphalidae Family of butterfly which was dominated with a high number of species and maximum diversity in Mharinginichi Rai sacred grove as compared to other sacred groves remaining.

Megha Rawat *et al*. (2011) found total of 239 plant species belonging to 78 families and 207 genera in the study area. Out of these, 9 species were considered threatened and 3 species vulnerable. Presently, the health of this sacred forest was deteriorating under constant anthropogenic pressures.

Xavier *et al*. (2013) identified around 67 plant species which were belonging to 35 families with 62 genera. Among these plant species, 48% were trees, 22% were herbs, 15% were shrubs, 12% were Climbers and 3% were under shrubs.

Jyothilakshmi *et al*. (2016) recorded 29 species of bryophytes. Among these, 10 are liverworts and 19 are mosses. The Bryum retusifolium was a new record to Kerala and Ditrichum tortuloides was a new record for Peninsular India.

Conclusion

Most of states of India covered from sacred grooves. There are 13,720 SGs has been reported which cover 39,063 ha area which is 0.055% of the total forest area of India. Thus, sacred grooves are the ideal centre for biodiversity conservation in India. Some important medicinal plants that are not to be found in the forest are which often concentrated in sacred grooves. SGs are full with rich biodiversity and harbor many rare species of plants and animals compared to other control site. These areas also provide habitat, water and nest-sites for many species of wildlife and birds. The religious belief, myths, deity and taboos are the constructive tools for conserving the rare, endangered, threatened and endemic species in sacred grooves. There is vast diversity among India's SGs, sometime grooves overlap with larger forest areas. In these patches, people do not cut wood for personal use. Thus, SGs play an important role in conservation of biodiversity and conservation of traditional knowledge.

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2019-2020

Seminar No. 1

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Minor Advisor: Dr. R. P. Gunaga	**Date:** 26/04/2019

MARKETING MECHANISM AND SUPPLY CHAIN OF AGROFORESTRY PRODUCE

Introduction

Marketing systems play a significant role in enhancing production and consumption and also helps in accelerating the pace of economic development (Huda *et al*., 2012 and Kapoor &

Kansal, 2003). Similarly, the marketing of agriculture, forestry, fisheries and agroforestry products plays a major role in smallholder's economy which are both produced and consumed locally. These products are contributing significantly to the GDP in developing countries like India (Dorwad *et al*., 2008 and Kohls & Uhl, 2002). The biological diversity of forest and their ecological functions are the heritage and provides goods and services to mankind. These forests are most important renewable natural resources which plays significant role in the economic prosperity and ecological stability of the country, which often leads to over exploitation of the natural resources particularly forest. The forests of India are shrinking at an alarming rate of 1.5 m ha per year (Parthiban *et al*., 2011) under acute socioeconomic pressure and the foresters at the cross roads to meet the demand through the agroforestry. The current forest cover of the country is 21.54 per cent (ISFR, 2017) and agroforestry cover is just 3.29% (ISFR, 2013). Indian forests are very low in productivity (0.7 m^3/ha/yr) as compared to the World average 2.1 m3/ha/yr and the per capita forest area in India is only 0.064 ha which is only 1/10th of the World average 0.64 ha (FAO, 2009).

Due to burgeoning population estimated 1.37 billion (World Population Review, 2019), India is under tremendous pressure to meet the ever-growing multifarious demand for wood and wood-based products. The gap of demand and supply of wood is widening over the years and the domestic supply of wood is insufficient to fulfill its growing demand; hence, imports of industrial wood have grown more than thrice in the last decade (ITTO, 2004). The current short fall of hardwood and softwood in total is 59% (Ahuja, 2016). Under such circumstances, the NFP, 1988 directed the wood-based industries to meet their raw material demand by establishing direct linkages with farmers through participatory approach (NFP, 1988). At present, total availability of wood in India is 79.9 m^3 of which 44.34 m^3 (62.5 %) wood come from the agroforest (Soujanya Shrivastava and Saxena, 2017). However, these activities are gaining slow momentum for want of suitable institutional mechanism to augment the traditional supply chain system (Parthiban *et al*., 2011). Indian agroforestry is dominated by small scale subsistence farming which has been not scaled up due to lack of institutional support. Farmers do not get proper prices for their agroforestry produce due to the unregulated involvement of many intermediaries in its value chain. There is paucity of literature on supply chain of agroforestry produce as well as there is no structured study is reported for most of the agroforestry produce. Therefore, the efforts have been made to collect the information from published and self assessed reports / focused group discussion to review on the aspect of marketing mechanism and supply chain of agroforestry produce.

Review of Literature

Supply chain of agroforestry produce at International level

Lazzarini *et al*. (2001) developed the concept of net chain which showed vertical relationship between the several value chain links and horizontal relationships between stakeholders' in the same link. Further they had explained that vertical relationship may follow all stages in the value chain or may not, and horizontal relationships between stakeholders had various shapes.

Weintraub and Epstein (2002) studied the supply chain for the forestry products and observed that the supply chains were integrated, multifunctional networks in both space and time that facilitates the transformation of raw material to finished products, which eventually were sold to customer or end-user.

Boston (2005) had illustrated the supply chain management planning process of forest products. He identified the five components of supply chain for forestry products for the proper planning such as supply, planning, forest planning, demand planning, execution and knowledge, collection and reporting.

Taraneh Sowlati (2012) elaborated the forest and agroforestry produce supply chain in Canada. She observed the various stakeholders such as sawmills, pulp and paper mills and veneer and plywood mills in the supply chain.

Kazi *et al.* (2014) studied the Forest Department (FD) controlled agroforestry timber distribution channel and observed four intermediaries and found that, the buyer / auctioneer intermediaries only arose in the FD controlled agroforestry timber / firewood marketing channel. Moreover, they had identified six intermediaries in supply chain in general agroforestry timber distribution channel in Bangladesh, where traders were dealing with only small volume of timber / firewood.

Magsi *et al*. (2014) studied the marketing channel of agroforestry products in Sindh, Pakistan. They had identified six intermediaries in marketing channel of wood and observed that the channels of wood products were different from other agricultural products because of different product transacted by different middlemen and stakeholders. Further, the team had worked out the marketing margin of eucalyptus products in Sindh area of Pakistan and noted that the maximum net margin earned by the saw miller were Rs. 10 per 40 Kg and minimum were earned by local assembler i.e. Rs. 7 per 40 Kg.

Anon. (2016) depicted the generic supply chain and related environmental and social impacts. It was observed that primary sector (sustainable forest management, harvesting, without permission logging, workers health and fare margin) might be negatively impacted in supply chain if not managed sustainably.

Ramudhin *et al*. (2008) studied the carbon market sensitive green supply chain network design. They illustrated the green design and green operations which reduced the emission, when product moves through channel from producer to ultimate consumer.

WWF (2019) explained the forest certification based supply chain of forest product. It was governed by the chain of custody certification, where the certification was done by third party with the assurance of the product harvested through sustainable management approach.

Supply chain of agroforestry produce at National level (India)

Negi (1998) worked out the major markets for the forest/farm/agroforestry products in India. They identified thirteen major markets distributed throughout India.

Subramanian and Senthilnathan (2004) studied the various operations in wood marketing and observed the seven stakeholders namely forest department, contractor, other government departments including railways, wholesale dealer, retailers and consumers. Further, they had

identified the market channel for the firewood in Hyderabad and observed nine stake holders, which included two producers namely farmer and forest department and three were consumers such as domestic consumers, social and religious and commercial consumers i.e. industry. In another study, they explored marketing in Hile-Basantpur road head, East Nepal and revealed that the supply chain was governed with three intermediaries between collectors and consumers in the interstate trade between India and Nepal.

NCCF (2017) depicted marketing channel for timber in India. They had identified five different channels for marketing of timber. It was observed that the channel I and II were important market channels with few deviations do exist. It was found that the Forest Development Corporations' directly supplied significant volume of wood to industries through allotment mechanism.

Parthiban *et al*. (2011) studied the status of supply chain of agroforestry for pulpwood in Tamil Nadu and found that the supply chain system was multi-partite and governed with unorganized supply chain and trade. Further, they had explored the existing supply chain of pulpwood. Study also showed that the channel had four stakeholders and intermediaries between grower and ultimate consumers i.e. industry. Moreover, they had studied the Quad-partite value chain model which was commonly called contract farming. This model incorporates research institutes, industries, growers and financial institutions for the efficient linkages to increase the profitability of the production system. They also compared the existing traditional value chain on industrial agroforestry that involved multi-partite stakeholders and profitable Quad – partite value chain. Further, the growers got maximum benefit with B:C ratio of 3.88:1 to 5.05:1 as compared to B:C ratio of 1.66:1 to 1.91:1 in the existing multi-partite model.

Negi and Ansari (2001) studied the existing marketing channels of eucalyptus and poplar-based agroforestry in Haryana and recorded that the existing market channels in the state were being practiced through three to five tier hierarchy system from self (grower/farmer), village level agent, contractor, industrialist which did sell their produce directly to any suitable agencies.

Singh and Grover (2001) studied the important marketing channels for eucalyptus. They had identified five hierarchy level among farmer to consumers.

Varadhraj *et al*. (2014) studied the distribution channels for wood-based products in Haryana. They had observed the involvement of various intermediaries functioning in between producer to consumer, which took away maximum share of the value of product. Further, they had explored the general marketing channel for major agroforestry products in Tamil Nadu and identified different marketing channels for agroforestry products such as timber, firewood, secondary wood, poles, pulpwood and matchwood. These marketing channels were governed by 3 to 8 hierarchy levels.

Bisen (2001) mentioned the marketing channel for medicinal plants-based agroforestry model and realized that the channel was governed by three hierarchy levels in which the middlemen and traders were the major players.

Mohindra (2001) studied the various practices of the wood markets of Punjab and he observed the various processes such as method of sale to trader and middlemen commission, loading, uploading, payment and deduction etc.

Ahuja (2016) examined the marketing linkages and employment potential of poplar-based agroforestry system in India and found that the channels did work simultaneously at various levels on Quada-partite model which did increase the benefit of the supply chain, particularly for the farmers or grower/producers.

Baksy (2013) depicted the value chain of bamboo in India. He observed considerable variation in length and size of value chain for Indian Bamboo based product industry which included different structure of the processing chain for different products. In this study total four intermediaries between cultivar and consumers were recorded.

Rao *et al.* (2009) assessed the value chain for Agarbatti in Tripura. It was observed that, in value chain, one per cent value was added locally. However, with Tripura Bamboo and Cane Centre (TRIBAC) intervention, this value rose to 10 per cent of the final value of goods.

ILFS (2006) studied the distribution of the profit in value chain of the Agarbattis, a bamboo product in Tripura. Total eight agents in the value chain were identified. The maximum benefit was governed by distributor and retailer and lowest was governed by cultivars of bamboo.

Conclusion

Agroforestry produce-based industry and value chain are very important, because they offer substantial opportunity for domestic farmers to increase their production and income. There is great opportunity for this sector to play a leading role in the development and establishment of the new wood-based industry under lining the 'wood is good' concept in India. However, it is clear from the recent research review that the presence of many intermediaries in the supply chain made it more complex and problematic for farmers and consumers. The existing marketing channels are being practiced through three to five tier hierarchies, wherein the farmers or growers are use to get the minimal benefits and the middlemen along with the traders gained maximum benefits. However, in institutional supported bipartite/ tripartite/ quad partite supply chain model for industrial agroforestry (especially pulpwood and plywood), the growers usually get maximum benefit, as compared to traditional system. The strong linkages among tree growers and industrial partners have resulted in smooth and timely buyback arrangements or contract farming for the farm grown industrial wood species. Mostly Eucalyptus, Leuceana and Casuarinas followed with Bamboo and Melia are being used for pulpwood, while Eucalyptus, Poplar, Rubber wood, Ailanthus and Semul are intensively cultivated for plywood. Overall study shows that there is a need to generate the data regarding market information of agroforestry produce. In order to develop well organized and efficient supply chain for agroforestry produce, there is a need of synergies and convergence regarding the production and marketing mechanism of agroforestry produce within framework of National Agroforestry Policy, 2014. This will regulate the supply of agroforestry raw materials to wood-based industries on sustainable basis to increase the share of agroforestry in household and national economy.

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Seminar No. 2

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Degree: Ph. D. Forestry (Silviculture & Agroforestry)	**Course No:** FOR 692
Major Advisor: Dr. M. B. Tandel	**Venue**: Room No. 101
Minor Advisor: Dr. M. J. Dobriyal	**Date:** 26/04/2019

AGROFORESTRY SYSTEMS IN WESTERN INDIA

Introduction

Agroforestry (AF) is collective name for land use systems and technologies where woody perennials are deliberately used on the same land management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In AFS there are both ecological and economical interactions between the different components (Lundgren and Raintree, 1982). The origin of agroforestry practices is believed to have been during Vedic era (Ancient period, 1000 BC) the agroforestry as a science is introduced only recently. The range of AFs from apparently simple forms of shifting cultivation to complex home-gardens: from systems involving sparse stands of trees on farm lands (e.g. Prosopis cinerariaKhejritree - in arid regions of Western India) to high-density complex multistoried homesteads of humid lowlands. The people in the arid zone of India since time immemorial have developed location specific Agroforestry systems. The scattered trees, shrub in the agricultural fields or grazing fields are common features of the landscape. Since the beginning of the cultivation the farmers deliberately allow the tree and shrubs to grow with the crops. They have screened the tree and shrubs based on their utility. They have considered that which trees are insurance to them during the drought year (Harsh and Tiwari, 2003). Agroforestry is fast becoming recognized as a sustainable land use system which is capable of yielding both wood and food while at the same time conserving and rehabilitating ecosystems. Acording to FSI report 2013 Aagroforestry area was reported 11.75 m ha in India and 3.98 m ha in Western India and. The Goa, Gujarat, Rajasthan and Maharashtra states come in Western India. (Anon., 2013). In future Agroforestry more contribution in domestic demands of various commodities like, Food, Fodder, Timer, TOBs, NTFP *etc*. AF perform a multitude of services to farmers, for farms and for the environment as a whole. Existing most common Agroforestry systemsin Western India are like,Shelterbelt, Wind break, Khejari, Ailanthus, Ber, Pomegranate, Acacia, Aonla, Neem, Mango, Teak, Bamboo, Eucalyptus and Arjuna based with other traditional AF systems [Singh et al. (2017); Tewari and Singh (2006) and Bhoyar *et al*. (2016)].

Brief review on Research work

Roy and Tewari (2012) recorded maximum fuelwood (1.23 t/ha/yr) and leaf fodder (0.9 t/ha/yr) production potential in Prosopis cineraria – Acacia niloticabased agroforestry system as compared to other systems. While, fuel wood and leaf fodder production were noted minimum in *Zizyphus* spp., *P. cineraria* and *Salvadora* spp.based AF system.

Ilorkar (2007) obtained maximumproduction of poles (150), volume (7.361 cum/ha) and gross monetary return (Rs. 169577.30) of teak from 8 X 2 m spacing of teak under silvipasture system as compared to 12 X 2 m spacing of teak.

Solanki (2018) reported significantly maximum economic returns under Sapota-Jatropha intercrop as compared to sole crops. The trend of economics in sole crop was Basil >Kalmegh> Mint; the trends was remained same when herbal crops was grown as an inter crop under Sapota-Jatropha. The highest BCR was recorded in basil (1:3.01) followed by kalmegh (1:2.86) and mint (1:2.31) when intercroped with Sapota-Jatropha as compared to sole crops.

Sondarva *et al*. (2018) recorded significantly maximum number of fruits per plant (24.89), average fruit weight (45.64 g) and yield (20357.35 kg/ha) in 100% RDF in open condition) which was at par with 100% RDF (100:50:50 NPK/ha) and 75 % RDF +Vermicompost treatments. While, INM treatment of T2: Azotobactor alone under teak based silvi-horticultural system reported minimum yield parameters.

Prajapati *et al*. (2012) evaluatedvariety (Sugandham and Kesar) of Curcuma longa and reported maximum yield under different trees species as compared to open condition. The maximum yield (14051.77), net realization (52293.63) and highest BCR (1:2.34) were found in Mitragynaparvifolia+ Var. Sugundha which was followed by *Casuarina equisetifolia* + Var. Sugundha, 1:2.05).

Bhusara *et al*. (2018a) reported highest seed yield (4.94 g/plant, 325.25 g/plot and 0.81 tonnes/ha) of green gram in T1 (sole cropping with variety Meha) while in case of intercropping maximum seed yield (4.54 g/plant, 298.92 g/plot and 0.75 tonnes/ha) was recorded in T7-(variety Mehaintercropped with M. composita at 4 x 2 m spacing).

Bhusara *et al*. (2018b) registered maximum fresh fruit yield (13.62 tonne/ha) in T2: Okra variety GJO-3 sole treatment which was at par with Okra variety GAO-5 sole. While in case of intercropping maximum fresh fruit yield was recorded in (13.62 tonne/ha) in *M. composita* (4x2) + Okra variety GJO-3 treatment which was at par with *M. composita* (4X2)+ Okra variety GAO-5, 12.97 tonne/ha.

Kazi *et al*. (2017) noted significantly maximum leaves of Colocasia per ha (321714.50) and BCR (1:6.56) when grown under highest density of Palmyra palm and it was gradually decreased with decrease in density of Palmyra palm while, minimum leaves of Colocasia per ha (228466.67) and BCR (1:1.84) was reported in open condition.

Roy and Tewari (2012) compared ber based agroforestry system and sole cropping system and recorded highest net profit (8000 Rs ha-1) in improved ber based agroforestry system as compared to sole cropping (4800 Rs ha-1).

Jaimini and Tikka (2007) found maximum grain and fodder yield of green gram in open condition (T7; 569 and 1331kg/ha; 330 and 1012 kg/ha and 303 and 902 kg/ha, respectively) in

three years. In case of average return, the maximum average return was recorded when crops grown in association with trees than open. Among different systems the Neem + green gram (8278 Rs/ha/year) registered more profit than other systems.

Jaimini and Tikka (2007)studied the economics of ber based agri-horti system and found ber + Green gram system gave more net realization (13099 Rs/ha/year) than other systems while Ber + Pearl millet system reported minimum net realization (9812 Rs/ha/year).

Ilorkar (2007) harvested maximum number of bamboo from application of 150 kg N/ha (N3: 24418) than other treatments. In case of BCR, maximum BCR was reported with application of 50 kg N/ha (N1: 1:1.69).

Patil (2011) studied the grain yield of rice under different directions from tree canopy and found maximum yield in north direction of all tree species with minimum percentage reduction than other directions. Moreover, maximum yield of grain was reported in open condition. Incase of intercropping, when the rice was grown under tamarinds tree reported maximum yield (24.5 q/ha) as compared to other.

Tewari and Singh (2006) studied the grain and straw yieldof mung bean and pearl millet with and without P. cinerariaand showed that green gram produce maximum grain (193 kg/ha) and straw yield (1803 kg/ha) in associated with 208 trees ha-1 than other density of trees and open. While, pearl millet reported maximum grain (165 kg/ha) and straw yield (5470 kg/ha) without trees.

Gajja and Ramdev (2016) registered maximum crop production (208.3 q/ha), employment (426 days) and net return [279135 Rs/farm (5ha)]under shelterbelt plantation in both season than non – shelterbelt. In case of various seasons, the Kharif Winter season was more profitable under shelterbelt plantation than Summer Rainfed.

Singh *et al*. (2007) studied the available macro and micronutrients in soils under Prosopis versus open fieldcondition and found more available macro and micro nutrients in different depth of soil under Prosopis based system as compared to open field.

Mertia *et al*. (2006) studied the per cent reduction of mean wind speed at different distances on the leeward side of different Shelterbelts at Jodhpur. The result showed more reduction of wind speed near the leeward side of shelterbelt while increasing distance from shelterbelt decrease the reduction of wind speed. Further among three tree species, Acacia tortilisreduced more wind speed as compared to other trees.

Saroj *et al*. (2003) recorded maximum yield of ground story crops in sole cropping system in the kharif season and perennial crop of aloe. Moreover in rabi season, the yield of ground storey crops was noted higher in closer spacing of 6 X 6m as compared to wider spacings of ber trees.

Bhati *et al*. (2009) studied several agri-horti practices and revealed that, Bael +clusterbean based agri-horti performed well with the higher B:C ratio (1:3.02) followed by Bael+ mothbean (1:2.86) and Bael + groundnut (1:2.75).

Sharma *et al*. (2009) registered significantly maximum biomass yield (86.37 q/ha) under Ardu + Cenchrus based silvipasture system.

Yadav *et al*. (2005) found significantly maximum yield of wheat grain (3666 kg/ha) and wheat straw (5538 kg/ha) under the sole cropping system as compared to under various MPTs. In case of various MPTs, the grain (3415 kg/ha) and straw yield (4809 kg/ha) of wheat was recorded higher under *P. cineraria*.

Patil *et al*. (2011) compared silver oak and natural shade and revealed that the survival percentage, growth parameters and yield of coffee were found highest under the shade of silver oak trees as compared to natural shade.

Bhagat *et al*. (2011) noticed higher average grain and straw yield of rice in sole cropping. Whereas in case of trees species and spacing it was noted higher under Acacia auriculiformis with spacing of 15m X 2m.

Bhati *et al.* (2009) studied different density of pomegranate under agri-horti system andfound that the yield of fruit and Gross return (Rs/ha) were higher under the trees planted in the density of 667trees per hectare.

Ilorkar (2007) suggested different tree species and pasture species combinations for different soil types i.e. shallow soils, shallow soils-medium soil, medium-deep soil.

Kumar *et al*. (2014) reported maximum gross return from the sole cropping of pearl millet and sorghum than their association with the simarouba tree.

Jaimini and Tikka (2007) observed maximum yield (48.50 q/ha) of dhaman (Cenchrusciliaris) when it is planted under the beneath of Khejri than the sole cropping (38.25 q/ha) and plantation in between the rows of Khejri (40.25 q/ha).

Jat *et al*. (2011) stated that the treatment combination of Ailanthus excelsa + C. setigerusperformed better with respect to dry fodder yield than the other two grasses with Ardu.

Roy and Tewari (2012) revealed that the average carrying capacity for sheep (8.5) was higher in Hardwickiabinata + Cenchrusciliaris based improved silvipasture system than sole grass (CC: 3.7) and sole tree (CC: 1.6) plantation at the age of seven years.

Harsh and Tewari (2007) reported highest economic return (Rs. 5019/ha) from the Hardwickiabinatabased silvi-pastoral systems than the sole cropping of both the species.

Singh and Singh (2015) found maximum biomass carbon (1.47 Mg ha^{-1}), soil carbon (3.60 Mg ha-1) and total carbon (5.07 Mg ha^{-1}) in the species combination of Cordia myxa + P. cineraria against the other species combinations and also sole cropping.

Pandey *et al*. (2017) noted maximum rhizome yield (61.23 q/ha) in the treatment G2: Sapota + Jatropha + Ginger var. Udaipur local which was found statistically at par with the treatments G6: Jatropha + Ginger var.Udaipur local (58.92 q/ha) and G1: Sapota + Jatropha + Ginger var. Navsari local (55.20 q/ha) while minimum rhizome yield (32.47 q/ha) was recorded in G3: Sapota + Ginger var. Navsari local.

Tewari and Mathur (2015) studied crop yield under different spacing of A. excelsa in silvi-agri-pastoral systems and stated that total straw and grain yield all crops were recorded maximum in 10 X 10 m spacing of arduand it was decreased with decrease in spacing. Among different crop Pearl millet recorded maximum yield (1655, 1740, 2056.3 Kg/ha, respectively) in different spacings.

Yadava *et al*. (2013) intercropped mung bean and cluster bean with citrus and reported highest total biological yield of mung bean (1412.5 kg ha-1) and cluster bean (1352.0 kg ha-1) in intercropping with citrus which was statistically at par with shisham. The same trend was observed in seed yield of both the intercrops. The highest seed yield of mung bean (471.3 kg ha-1) and cluster bean (419.8 kg ha-1) were recorded with citrus.

Conclusion

The Western part of India is having seven agro climatic zones with varied kind of ecological situation from the erratic and scanty rainfall to heavy rainfall. It includes the states of Goa, Gujarat, Rajasthan and Maharashtra. AF plays a major role in improvement of Western India's economy by improving soil fertility and health, increasing the farm income, generates employment and support the livelihood of the people. Agroforestry is an age old practices in western part of India. The farmers are practicing shifting cultivation, growing agricultural crops in the shade of trees, inter-cropping under coconut and home gardens traditionally. However, the most common existing agroforestry systems in the western India are Agri-silviculture (AS), Agri-horti-silviculture (AHS), Agri-horticulture (AH), Agri-silvipasture (ASP), Silvi-pasture (SP), Agri-Sivi-pastoral and Horti-silviculture (HS). The most preferred tree species for agroforestry in Western part of India are Mangifera indica, Ailanthus excelsa, Punica granatum, Tectona grandis, Eucalyptus spp., Casuarina equisetifolia, Prosopis cineraria, Acacia nilotica, Zizyphus spp., Salvadora spp., Acacia auriculiformis, Borassus flabillifer, Azadirachta indica, Hardwickia binnata, Citrus spp., Emblica officinalis, Bamboo spp., Cocus nucifera etc. The most common preferred Food, Vegetable and fodder crops in Agroforestry systems of Western India are Pearl millet, Rice, Coffee, Groundnut, Sesamum. Mustard, Cluster bean, Cowpea, Wheat, Sorghum, Sugarcane, Colocasia, Turmeric, Ginger, Green gram, Horse gram, Moth bean, Brinjal, Okra, Napier, Stylo hamata, Cenchrus ciliaris, C. setigerus etc…

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Seminar No. 4

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WASTE TO WORTH: AGROFORESTRY COMPONENT BY-PRODUCT PERSPECTIVE

Introduction

Agroforestry is a complex land use systems where diverse products are yielded and hence the chances of unutilized products are higher. Recent rapid growth of the world's population has increased food demands. Driven by this issue, the demand and production of agricultural products have been increasing and this trend is likely to continue in the future (Kearney, 2010). In this backdrop, scientists and policy makers advocate agroforestry as viable land use system. Consequently, may it be agroforestry or other agricultural land use systems, there would be chances of varied wastes due increased production in response to desired outputs for escalated demographic figures. Hence, agricultural waste production would also increase. This is resulting in the availability of increased by-products and wastes for various applications. If not managed or utilized in time and in efficient way these by-products may cause ecological imbalance e.g. present situation of our National Capital Region, ascribed to burning of wheat and paddy or other crops stubble.

Therefore, it is important to create opportunities to utilize these agroforestry wastes for obtaining an array of value-added products having applications in food, pharmaceutical and allied industries. The main value added products that can be produced from fruit and vegetable wastes/residues include enzymes, reducing sugars, furfural, ethanol, proteins, amino acids, carbohydrates, lipids, organic acids, phenols, activated carbon, degradable plastic composites, cosmetics, biosorbent, resins, medicines, foods and feeds, methane, biopesticides, biopromoters, secondary metabolites, surfactants, fertilizer and other miscellaneous products. Agroforestry by-products could also be in seed bio-priming, seedling production in nurseries, making biofertilizer, as mulch material to enhance crop production and soil fertility, soil health etc.

Therefore, there is need to utilize agroforestry land use waste as beneficial by-products to curve down the waste menace and safeguard the environment.

Brief review of research works

Agroforestry by-product (Woody component) waste utilization

Hanif *et al*. (2015) evaluated the response of different leaf litter biomass of different agroforestry species having 10 different treatments on the yield of rice (BRRI DHAN 49) and they revealed that, highest yield (5.66 tha-1) was recorded in T0 (recommended doses of chemical fertilizer). Among the treatments with leaf biomass, maximum yield was recorded in T3 (300 g of Albizia) 5.23 tha-1 followed by 5.04 tha-1 in T6 (300 g of Leucaena). They concluded that rice can be cultivated successfully with leaf biomass as a low cost environment friendly sustainable production system.

Majumder *et al*. (2008) conducted an experiment to study the effect of different doses of tree leaf litter on the yield and yield contributing characters of transplant Boro rice cv. BRRI Dhan28. They found highest amount of nutrients was released from 12.5 ton ha-1 leaf litter and 5 ton ha-1 was lowest. The highest grain yield (5.24 t ha-1) was recorded under recommended fertilizer dose followed by 4.98, 4.78, 4.66, 4.50 obtained out of the treatments of 12.5 ton leaf litter ha-1 (4.98 t ha-1), 10 ton leaf litter ha-1 (4.78 t ha-1) 7.5 ton leaf litter ha-1 (4.66 t ha-1) and 5 ton leaf litter ha-1 (4.50 t ha-1), respectively and concluded that organic matter of the post harvest soil increased considerably due to the treatments as compared to initial soil.

Brunetti *et al*. (2005) studied the effects of the addition of either crude or exhausted olive pomace at two rates (10 and 20 t ha-1) on soil and soil humic acid (HA) properties and durum wheat (Triticum turgidum L.) Soil amendment with olive pomaces produced a significant increase of total organic. The enhanced amount of organic matter in pomace amended soils appears to play a major role in improving wheat performance, possibly by increasing moisture retention in amended soils, thus minimizing the water deficit effects from wheat anthesis to maturity and concluded that the increase of grain yield in soils amended with olive pomaces may be primarily related to the increased number of kernels per square meter and kernel weight and secondarily to the increase of spikes per square meter and decrease of kernels per spike.

Khan *et al*. (2010) conducted experiment to find out the response of different leaf litter on yield of rice (cv. BR11) of 15 different treatments. They found that the Neem (300g Neem leaf biomass) treatment gave the highest grain yield and that of Arjun was the lowest. There was no significant effect on 1000 grain weight. The highest grain yield (5.66 t ha1) was recorded in the treatment T6 (300g Neem leaf biomass) followed by mahogany (second highest) treatment and concluded that tree leaf biomass, Neem and Mahogany treatments were found the best therefore different combination of leaf biomass with recommended fertilizer dose maximizes the rice yield.

Sirohi *et al*. (2016) investigate to assess the feeding strategy comprising Prosopis juliflora pods (PJP) in two forms as alternative feed resource for sustainable goat production for dry season in arid areas. Eighteen growing goats (Marwari and Sirohi breed) were distributed into three groups. The results revealed that the feeding of concentrate mixtures containing either 50%

ground or entire PJP to the arid goats did not adversely affect growth performance, reproduction and cud chewing. Moreover, the adopted feeding strategy made Prosopis juliflora incorporated concentrate diets more economical than the commercial one.

Lengarite *et al*. (2014) conducted experiment to determine the effect of feeding processed (milled Acacia tortilis pods and chopped grass hay) and unprocessed (whole Acacia tortilis pods and long grass) dry season supplementary feeds on milk yield of goats, growth response of suckling kids and their economic effects. The results showed that daily intakes of chopped grass (309.5 g), whole ATP (413.1 g) were higher than long standing grass (165.4 g) and milled ATP (186.4 g). Of the supplement diets, whole Acacia tortilis was the most consumed (87.7%) followed by milled ATP (67.3%), chopped grass (51%), while long grass (40.4%) was the least. They found that processing by milling of Acacia tortilis pods improved digestibility, while chopping of grass hay increased intake and inclusion in the diet as quality supplements milled and whole *Acacia tortilis* pods can alleviate nutritional constraints in the dry season, increase milk yield and sustain the body condition of pastoral goats in the arid rangelands.

Sukhadiya *et al*. (2019) reported that ooverall, the proximate principles, mineral matter and total phenols content found in *M. dubia* drupe pulp are in permissible limits (considered good for livestock feeding). Further, the pulp of M. dubia can be included in mineral, fat, carbohydrate and energy rich feed source category. The investigation divulged that M. dubia drupe is a good alternative/agro-industry by-product (pulp extracted from drupes to raise seedlings) as a feed source for small ruminants and cattle.

Anbu *et al*. (2017) conduct a study to formulate growth media using fruits peel waste materials such as Pine apple, Mango, Jack fruit, Green Banana, Yellow Banana, Sweet Lime and Pomegranate. Aspergillus niger growth was recorded in the medium containing Pine apple, Mango, Jack fruit and Green banana except Yellow banana, Sweet lime and Pomegranate. Rhizopus stolonifer growth was observed in Pine apple, Mango, Sweet lime and Pomegranate medium and it was not recorded in the medium containing Yellow banana, Jack fruit and Mango. However, the Penicillium chrysogenum growth was recorded in Pine apple, Mango, Sweet lime and Pomegranate medium and it was recorded in the medium containing Yellow banana, Jack fruit and Mango.

Poovarasan *et al*. (2019) observed that the seed of black gram treated with papaya seed extract 2.5 percent showed the higher activities of enzymes like dehydrogenase activity (2.79 OD value) observed in papaya seed extract 2.5 per cent followed by pomegranate peel extract 7.5% (2.55 OD value) and papaya peel extract 5% (2.52 OD value). The lowest dehydrogenase activity (1.58 OD value) registered in non primed seeds and other treatments. They reported that, reported that the seeds treated with 5 % Papaya peel showed the highest seed germination (77%) when compared to the control (72%). Five per cent papaya peel extract resulted in maximum root length (15.2 cm). Papaya peel extract at 5 % and papaya peel at 2.5 % showed maximum shoot length (12.6 cm). Dry matter (258 mg seedlings-10), vigour index I (2138) and vigour index II (19.87) recorded maximum in papaya peel extract at 5 %. They also also revealed that the seeds treated with 7.5 % pomegranate peel extract recorded high physiological changes in terms of

germination percentage, seedling length, root length, dry matter production and vigour index in black gram, as compared to rest of treatments and control.

Further, they revealed that the seeds treated with 2.5 % Papaya seed extract recorded high physiological changes in terms of field emergence, germination percentage, seedling length, dry matter production and vigour index in black gram, when compared to rest of treatments and control.

Mercy *et al*. (2014) observed that fruit peels of Banana, Pomegranate, Sweet lime and Orange formulated from the trace amounts and gradually increased for the preparation of three formulations as Formulation 1 (1 g peel powder+ 100 ml water), Formulation 2 (3 g peel powder+ 300 ml water) and Formulation 3 (6 g peel powder+ 600 ml water).. From three different formulations maximum N, P and K content was highest in formulation 3.

Agroforestry by-product (Non-woody component) waste utilization

Mishra and Koshy (2016) studied the effect of different concentrations of waste extract and decoction of Solanum lycopersicum pulp on its own seed germination and growth. Results indicated that all extract/decoction concentrations promoted seed germination, also contributed to seedling height, plant growth and biomass accumulation compared to control. However, an increase in dilution ratios from 1:5 to 1:8 had a significant effect on germination and growth of tomato plants.

Findings of Roy *et al*. (2006) indicated that among the extracts from different parts of banana plant, extract was beneficial at lower concentration for germination and seedling growth of red amaranth, amaranth, radish, cucumber, ribbed gourd, bean and okra.

Barh *et al*. (2018) evaluated effect of self fruit extract and vitamin – C on tomato seed germination. They found that 2% tomato extract required very less hours for 50% germination of tomato seed as compared to control condition. While higher concentration of ascorbic acid inhibited the seed germination.

Villena *et al*. (2018) investigated the effect of three different compost (derived from winery and distillery waste) dose levels: 7 (D1), 13 (D2) and 20 (D3) t ha–1 and a control (D0) without the application of compost. They reported that the application resulted in modest increases in plant biomass and leaf area index and improvement in melon fruit yield. The 13t ha−1 (D2) compost dose was enough to achieve the highest yield.

Sall *et al*. (2019) evaluated grocery stores leachates at different dilution rate and reported that compost leachate at 0%, 25%, and 50% dilution inhibited cress germination, but for corn, 47% of the seeds germinated in the leachate without dilution was achieved.

Pal et al. (2001) from long term investigation on rice-wheat crop residue management concluded that residue incorporation improved OC, available N, P, K over residue removed or burned.

Chatterjee *et al*. (2017) recorded increased OC and C:N ratio in Wheat straw + Cow dung, while total (N%+K%) and total P% was maximum in mixture of vegetable residue + cow dung + earthworm and Cow dung + earthworm, respectively.

Project report (NAU, Navsari, Gujarat, 2014) on “A Value Chain on Utilization of Banana Pseudostem for Fibre and Other Value-Added Products (NAIP)”, revealed that the

enriched sap increases the pod yield of summer vegetable crops viz., okra, cluster bean and cowpea was 31, 30 and 20 per cent, respectively. In case of banana, an increase in fruit yield was 23 per cent and in cereals the increase was around 11 per cent. Report concluded that sap can be used for replacement of fertilizer.

Kasapidou *et al*. (2015) reviewed that functional ingredients like polyphenols, hesperidin, carotenoids, polysterols, fattyacids can be obtained from fruit and vegetable processing co-products.

Wadhwa *et al*. (2015) reviewed that fruit and vegetable waste could be a good source of bioactive compounds like Polyphenols, Limonoids, Syringic acid, quercitin, mangiferin, Gallic acid and these can be used as substrates for microbial fermentation for enzyme production like a-Amylase, hemicellulase, Pectinase, Phytase, Carboxymethyl cellulose.

Conclusion

The literature review indicates that different wastes from agroforestry components could be utilized as beneficial by-products. Wastes from different woody and non woody components could efficiently be utilized in seed priming, enhancing seedling growth. The left over of understorey crops could also be utilized for soil fertility improvement by converting them in composts either singly or in in mixture. These wastes are also good source for making bio-fertilizers. The fruit and vegetable wastes are rich sources of energy, protein, minerals and vitamins; and therefore, have great potential as feed for livestock. Pomace/pulps, peels, seeds of many fruits and vegetables can be used as dietary fibre supplements and as a functional ingredient in developing processed food products having health benefitting effects. These can also be used for the production of various bioactive compounds. Therefore, there is need to look forward to utilize all wastes from agroforestry land use to maintain better ecological conditions.

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Seminar No. 5

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Degree: M.Sc. Forestry (Forest Products & Utilization)	**Course No:** FOR 591
Major Advisor: Dr. B. S. Desai	Venue: Room No. 101
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PRODUCTION TECHNOLOGY OF *WITHANIA SOMNIFERA* (L.) DUNAL

Introduction

Withania somnifera (L.) Dunal, also known widely as ashwagandha, Indian ginseng or winter cherry, an herbaceous plant belonging to the family Solanaceae. In all 23 of species of the genus Withania are recorded from wild. Ashwagandha in Sanskrit means "horse's smell" (ashwa - horse, gandha - smell), probably originating from the odour of its root which resembles that of a sweaty horse. The species name somnifera means "sleep-inducing" in Latin (Khare, 2010). It is one of the most used medicinal plants, the roots of which have been employed in Indian system of medicines viz Ayurveda and Unani. It is popular Indian medicinal plant and has been used for

over 3000 years in Ayurvedic medicine to treat diverse range of diseases such as insomnia, infertility, rheumatoid arthritis and gout. Ashwagandha is member of the drug called rasayana i.e. tonic. Economically important plant parts are root and leaves (Anonymous, 2010). The principle chemical components are called as Withanolides such as Withaferine, Withasomnine and Withaferone (Gupta, 2013).

It is native to India and the Mediterranean region in North Africa, and it is widely distributed in Pakistan, Sri Lanka, South Africa, Iraq, Iran, Syria, and Turkey. In India, ashwagandha is commercially cultivated in Madhya Pradesh, Gujarat, Maharashtra, Rajasthan, Haryana, Punjab, Karnataka, and Uttar Pradesh provinces. In the Neemuch and Mandsaur districts of Madhya Pradesh province alone the cultivated area exceeds 5000 hectares (ha) and, in India overall, approximately 10,770 ha of land are used to grow ashwagandha with an annual production of 8429 metric tons. Various herbal preparations of Ashwagandha are available in the market. In October 2018, costs for high quality dried ashwagandha roots varied between US $2.46 – 3.56 on the Indian market (although roots considered as lower grades, known as tar, were sold for as little as US $1.50), compared to US $0.34 – 0.82 for dried ashwagandha leaves (Singh, 2018).

Brief review of Research Work

Shanmugaratnam *et al*. (2013) studied the effect of seed treatments in Withania somnifera and found that highest germination (52.75 %) is obtained when seeds were treated with hot water for 24 hrs.

Ganvit (2016) conducted experiment on effect of different seed treatments and media on growth of Withania somnifera. Pre -sowing treatments (S1) [GA3- (250 ppm) - 24 hrs] gave higher germination (66.11 %). Interaction effect of pre-sowing treatments (S) and different media (M) on germination percentage was also recorded. Maximum germination (80 %) was obtained in treatment combination of S1M3 - GA3 (250 ppm - 24 h.) sowed in Red soil + Vermicompost + FYM.

Kambizi *et al*. (2006) conducted studies on effect of pre-chilling treatments and light on seed germination in Withania somifera. They concluded that maximum germination percentage (46.0 %) was obtained when seeds were not given any pre chilling effect with alternate light/ dark photoperiod (16/8 h photoperiod). On the contrary, pre chilling treatments with constant (16/8 h photoperiod) decreased the seed germination in Withania somnifera.

Kumar *et al*. (2016) worked on effect on different temperature on seed germination in Withania somnifera. It was found that highest germination percentage (92.00 %) and seedling vigor SVI II (0.2583) was obtained at alternating temperature of 15/350C whereas SVI 1 (344.5) was maximum at 150C temperature. Temperature of 200C and 250C did not produce satisfactory results.

Desai (2010) studied effect of various spacing and fertilizer levels on growth and root yield of Withania somnifera and observed that plant height (49.28 cm) was maximum in treatment S1, whereas no. of leaves / plant, root length, fresh root weight/plant and dry root weight were highest in treatment S3 with values of (268.24, 26.10 cm, 5.14 g & 2.06 g)

respectively. Similarly, treatment F3 gave maximum values for parameters like plant height (58.11 cm), no. of leaves / plant (275.64), root length (26.77 cm), fresh root weight/ plant (5.43 g) and dry root weight (2.13 g) respectively.

Chaudhary and Datta (2014) conducted research on effect of various manures and water soaking treatments (24 hrs & 48 hrs) on the germination rate of Withania somnifera variety JA (Jawahar Ashgandh 20) and JA (Jawahar Ashgandh) 134. Results for variety J.A-20 indicates that highest seed germination (87 %) was recorded in treatment T1.1, lower (58 %) in T2.2 and the minimum (52%) in control when seeds are soaked for 48 hrs in water. Days required for onset of germination was lowest in treatment T1.1 – 07 days. Treatment T1.3 gave highest germination index (8.63). For variety J.A-134 highest seed germination (77 %) was recorded in treatment T1.3, lower (60%) in T1.1 and the minimum (45%) in control when soaked for 48 hrs in water. Similarly, for JA 134, maximum germination index (8.12) was recorded in treatment T1.3 when soaked for 48 hrs in water. In both the varieties, JA 20 & JA 134, treatment T1.3 soaked for 48 hrs in water gave better results.

Saidulu *et al*. (2014) studied effect of various heavy metals – Cadmium, Nickel and Chromium with different soil media on morphological parameters in Withania somnifera and they observed that maximum plant height (34.20 cm) was found in soil + heavy metal 1% + Ca (OH) 2, whereas other parameters like no. of branches (2.67), no. of leaves (29.39), no. of fruits (15.50), fresh weight of roots (4.59 g), dry weight of roots (0.429 g), fresh weight of whole plant (31.23 g), dry weight of whole plants (5.42 g) and leaf area (10.27 sq.cm) were maximum in control soil as compared to soil treated with heavy metals. Heavy metals decreased the overall growth in Withania somnifera.

Ratre and Dewangan (2018) experimented on growth parameters & seed yield of Withania somnifera as influenced by sowing method and organic manures and found that maximum plant height (84.10, 87.36 cm), number of leaves/plant (174.03, 188.02), number of primary branches/ plant (16.42, 18.17), number of secondary branches/plant (10.63, 11.06) and seed yield (182.21, 214.00 kg / ha) were obtained in treatment M3 (raised bed method in main plot – sowing methods) & S3 (sub plots – organic manures) at the time of harvesting (>120 days). In context to no. of secondary branches and seed yield kg ha-1, treatment M3 and SA3 was far better with values of (10.63, 11.06) no. of secondary branches & seed yield was (182. 21 kg/ha-1, 214.00 kg/ha-1) respectively.

Kubsad *et al*. (2009) conducted experiment to observe the effect of sowing time as well as stage of harvesting in Withania somnifera. They observed that crop sown on September 15th irrespective of harvesting stages recorded significantly taller plants (63.7 cm), more branches/plant (5.6), more canopy spread (26.4), higher root length (37.7 cm), more root diameter (0.96 cm) and fresh root weight (7.076 g) as compared to other sowing dates. Among the different harvesting stages, the crop harvested at 180 DAS had higher plant height (64.3 cm), branches/plant (5.6), more canopy spread (26.6), higher root length (37.7 cm), more root diameter (0.99 cm) and fresh root weight/plant (6.711 g) in comparison to other harvesting stages.

Shukla & Shukla (2012) carried out research on effect of various PGR on root production in Withania somnifera. Data revealed that 3000 ppm concentration of CCC had significant effects on the weight of fresh root /plant (29.83 g), dry root weight/plant (6.47 g), dry root weight/plot (180.89 g) and dry root weight/ha (8.37 g) in comparison to other treatments of IAA and GA.

Kumar *et al*. (2009) carried out experiment on effect of various bio fertilizers and organic manures on growth of Withania somnifera var. rakshita and observed that maximum root yield (1185.6 kg ha−1), seed yield (208.13 kg ha−1), number of shoots per plant (6.07) and plant height (108.4 cm) were obtained in treatment T6 (organic manure [OM] 20 t ha−1+ both bacterial strains – Azotobacter chroococcum & Psuedomonas putida). Also the highest net return was with treatment T6 (Rs. 53,272 & B: C ratio of 3.32) and T9 (OM) – 10 t ha−1 + both bacterial strains) (Rs. 44,763 & B: C ratio of 2.94) respectively.

Kumar *et al*. (2017) studied interaction effect of fertility levels and moisture conservation practices on fresh weight of root in *Withania somnifera* and found that maximum dry weight of roots (11.38 q / ha, mean value of 9.45 q ha-1) was obtained in treatment F5M3 in comparison to other treatment interaction.

Ahirwar *et al*. (2017) studied root yield in Withania somnifera intercropped with pulses and oil seeds. Maximum root yield (518 kg/ha) was obtained in sole crop as compared to other treatment combinations.

Shrivastava *et al*. (2018) studied integrated nutrient management on growth & productivity of *Withania somnifera*. They concluded that highest root length (15.4 cm), root girth (2.06 cm), dry root (555.8 kg / ha) and seed yield (59.2 kg / ha) was obtained in treatment T14 (50 % NPK + 5.0 ton / ha FYM + 2.5 ton / ha vermi-compost + 20 kg ZnSO4).

Borade *et al*. (2018) carried out their research on management of root rot disease in Withania somnifera with bioagents and fungicides. Maximum (246.14 g) dry wt. of root/plot was obtained when seeds were treated with treatment T3 (Mancozeb 63 % + Carbendazin 12 %) and (182.14 %) alkaloid per plot respectively.

Goel and Duhan (2014) carried out studies on effect of FYM & inorganic Phosphorus on growth, yield & alkaloid contents in Withania somnifera. Maximum dry weight of root (4.08 kg/ha) and dry weight of shoots (5.79 kg/ha) and yield of alkaloids (20.4 mg/pot) were obtained in treatment with P @ 37.5 kg/ha and FYM level @ 37.5 t/ha. Maximum plant height was recorded in same treatment i.e. P @ 37.5 kg/ha and FYM level @ 37.5 t/ha.

Shrivastava and Sahu (2013) studied integrated nutrient management in Withania somnifera. The gross returns was maximum (Rs. 61,280 ha−1) under treatment T11 (100 % NPK + 2.5 tha^{-1} vermi-compost + 5 tha^{-1} FYM + 20 $kgha^{-1}$ ZnSO4). The lowest (Rs. 28,230 ha^{-1}) gross return was under treatment T2 (50 % recommended dose of NPK – 20:10:10). The net income was highest (Rs. 38,270 ha^{-1}) under treatment T11. The lowest (Rs. 15,240 ha^{-1}) net income was recorded under treatment T2 (50% NPK fertilizers alone). The mean benefit-cost ratio was maximum (2.66) under treatment T11, whereas the minimum benefit-cost ratio (2.07 and 2.12) was obtained under treatments T7 and T8 respectively.

Shamaraj *et al*. (2012) studied impact of planting dates & stage of harvesting on yield and economics in Withania somnifera. The results showed that, planting on IInd forth night of July recorded the highest dry root yield (819 kg ha^{-1}) and seed yield (341 kg ha^{-1}) respectively. Planting on II forth night of July recorded the highest net return of Rs. 42,217 ha-1 and B: C ratio of 6.76. The dry root yield and seed yield of Withania somnifera harvested at maturity stage were 837 kg ha^{-1} and 325 kg ha^{-1} respectively and also Withania harvested at maturity stage recorded significantly higher gross returns (Rs. 51,352 ha^{-1}), net returns (Rs. 43,067 ha^{-1}) and B: C (6.48) when compared to rest of the treatments that are also attributed to increase seed production and root yields.

Kumar *et al.* (2013) carried out in vitro studies for rooting response in two cultivars W. S cv. Jawahar (WS1) and W. S cv. Local (WS2) of Withania somnifera. Maximum root induction (64.0 %), root no/explants (12.8) and root length (11.0 cm) were recorded in treatment of MS media+ IBA (5.0 mg/l) in W. S cv. Jawahar (WS1). Similarly, for cultivar W. S cv. Local (WS2), treatment MS media + + IBA (5.0 mg/l) proved to effective with maximum root induction (60.1 %), root no/explants (10.6) and root length (9.2 cm) respectively.

Ara and Chaudhary (2014) worked out on in vitro multiplication of Withania somnifera and observed that out of three different Auxins IAA, IBA and NAA tested in different concentration, IBA 1.0 mg/l produced higher (93.3 %) cultures with root and (8.2) no. of root/explant when compared to various concentrations of IAA and NAA respectively.

Conclusion

Germination percentage is highest when seeds of Withania somnifera are soaked in hot water for 24 hrs. Also, pretreatment of seeds with GA3 – 250 ppm combined with red soil & vermicomposting also enhance the germination and growth in Ashwagandha. Light has profound effect on seed germination in ashwagandha, whereas pre chilling treatment is not effective as seed germination. Light duration of 16 hrs & dark period of 8 hrs increases the seed germination. Seedling vigor index is affected when seeds are exposed to periodic temperature regimes of 15/350C. Spacing of 45 cm x 30 cm increase plant growth. Fertilizer application 25-25-0 NPK also has significant effect on growth and dry root weight in Ashwagandha. Combined effects of seed treatment with various manures also gave good results in Ashwagandha cultivars J.A 20 and J.A 134. While various media and manures have significant impact on growth and seed germination, heavy metals like Cadmium, Nickel and Chromium tends to decrease the overall performance of Ashwagandha. Various sowing methods are employed for better yield and growth, among which raised bed method in combination with FYM is better treatment for production of seeds in Ashwagandha. Harvesting stage at 120 days or more than 120 days produces more roots if proper sowing time is taken into consideration. Bio fertilizers such as Azotobacter & Psuedomonas also increase plant growth. Disease management is major aspect in production technology. Mancozeb & Carbendazin are effective to control root rot disease in Ashwagandha. FYM, inorganic Phosphorus coupled with integrated nutrient management is also beneficial. In vitro studies revealed better rooting when MS media is supplemented with IBA – 1.0 mg/l and 5.0 mg/l, respectively.

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Seminar No. 6

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Degree: M.Sc. Forestry (Forest Products & Utilization)	**Course No:** FOR 591
Major Advisor: Dr. M. B. Tandel	**Venue**: Room No. 101
Minor Advisor: Dr. V. M. Prajapati	**Date:** 07/12/2019

PRODUCTION TECHNOLOGY OF EUCALYPTUS (*EUCALYPTUS* SPP.)

Introduction

Eucalypts has a long cultivation history in India. It was first planted around 1790 by Tipu Sultan in the Nandi hills near Bangaluru. Over 170 species and various intra specific variations were tested in India. Currently, India is one of the largest Eucalypt growing countries in the tropics with an estimated area of over 20 million hectares (Venkatraman, 2015). In the last century, the genus Eucalypts became an important multipurpose source of timber in many industrial applications for production of pulp and paper, charcoal, energy, furniture, and housing. A large genus of evergreen aromatic tress, rarely shrubs, indigenous to Australia, Tasmania, New Guinea and the neighboringislands, where they constitute a large portion of the forest vegetation, giving it a characteristic appearance and comprising of over 700 species. Various species of Eucalyptusare cultivated, particularly in sub-tropical and warm temperate regions,on account of their economic value, Eucalyptus species (Family- Myrtaceae) are remarkable for therapid growth and some of them, in their natural habitat, attaingigantic sizes and are among the tallest trees of the World. Most ofthe species are popularly called GUM TREESin Australia, althoughthe exudation from them is not a gum, but an astringent, tanniferoussubstance called KINO (Shah *et al*., 2016).

Due to short rotation period and easy adaptability to a wide variety of soils and climatic factors *Eucalyptus* spp. are amongthe most extensively cultivated species in India under major afforestation programmes.Eucalyptus plantations are raised with an objective of providing raw material for the pulp and paper industry,woodbased industries and also to meet the fuel wood requirement (SriLaxmiand Rao, 2017).

Brief review of Research work

Murugesan *et al*. (2016) reported that treatment comprising of Coir pith+ All composts+ PGPR + PPFM +AM fungi + NSC + ASCshowed higher germination percentage (66%) followed by T5: Coir pith+ All composts (64%) and T12: Vermiculite + All composts + PGPR + NSC + ASC + PPFM + AM fungi (63%). Though high germination percentage was recorded in coir pith based potting mediaT_5 and T_6, over all better seed germination behaviour was noticed in vermiculite based potting media as comparedto coir pith base potting media. Moreover, maximum shoot height (46.12 cm), collar diameter (4.46 mm) and dry weight per plant (2.99 g) in coir pith base potting medium T6, whereas in case of vermiculite based medium T12reportedshoot height (24.75 cm), collar diameter (3.78 mm) and dry weight per plant (2.64 g) after 60 days.

Gunjan Patil and Umadevi (2014) revealed that among the two heavy metals (cadmium and lead), the cadmium exhibited maximuminhibitory effect on the germination of

foureucalyptus species after 21 days of sowing and it ranged from 6.67 % to 49.33 % and the lead showed minimumreduction in germination which varied from 26.67 % to 52.00 %. Among the four eucalyptusspecies taken for thisstudy, *Eucalyptus citriodora* was least affected andregistered significantly highest germination (49.33 %)while Eucalyptus tereticorniswas most affectedwhich registered lowest germination of 6.67 % as compared to control for cadmium. For the lead, *Eucalyptus* citriodora and *E. globulus* was leastaffected and showed maximum germination (52.00%) while *Eucalyptus tereticornis* was most affectedwith germination of 26.67 %.

Affonso *et al*. (2018) conducted a germination test with E. phaeotrichaseeds on paper at 30 ºC and recorded first count after 6 days of sowing. Number of seedlings gradually increased up to 14 days after sowing and then stabilized. They also noted maximum germination at 20-30 °C and minimum germination at 20 and 35 ºC. However in case of germination speed index, the temperatures of 15, 20, 35 and 20-30 °C were the most harmful ones, although the last two, 35 and 20-30 °C, did not differ from 25 °C. The highest values of first count was reported in 300C temperature moreover, lowest values of the first count test were found in seeds kept at 15 and 20 °C. The mean time for germination of seeds was reduced at 25, 30 and 35 ºC.

Makawana (2011) recorded maximum survival percentage (68.09%) in cuttings treated with IBA 4000 ppm followed by IBA 5000 ppm(61.96%). Significantly, the lowest survival percentage (36.59%) of cuttings was recorded under control. Moreover, hardwood cuttings (C3) showed the maximum survival of rooted cuttings (57.82%) was superior over semi-hardwood (52.46%) and softwood cuttings (50.63%). However, in case of interaction effect, the combined effect of IBA at 4000 ppm and hardwood cuttings, resulted in the highest survival of 79.17%; whereas, the lowest survival of recorded under control.

Prasad *et al*. (1996) found highest percentage of rooting in cuttings treated with 4000 ppm IBA (diluted with 50% alcohol and water).

Dhiman and Gandhi (2014) recorded highest rooting percentage (25.91%) in cuttings of Mysore gum treated with 10000 ppm IBA and lowest percentage of rooting (4.3%) in untreated cuttings of Mysore gum.

Venkataramanan *et al*. (2015) observedmaximum rooting percentage (76%), average number of roots (15.33±1.33) and average root length (3.93±0.86 cm) in the cuttings of untreated (with hormone) for the hybridEc 111 x Et 86 cross followed by 63 % rooting percentage in the cuttings treated with 100ppm IBA (10minutes). However, in the cross Ec 7 x Et 88, maximum rooting (95%), average number of roots (14.33±0.66) and average root length (5.19±0.79 cm) were observed in the cuttings treated with IBA100ppm (10minutes) as compared to control.

Joshi *et al*. (2003) observed that out of 24 bud explants inoculated only 8 remained green from the beginning, responded to the cultural conditions. BAP alone did not facilitate any bud break. After 90 days of inoculation shoot buds started multiplying in 1.0 mg/l BAP + 1.0 mg/l NAA and after 150 days from a single bud 20–25 buds multiplied. Further, proper elongation was observed in ½ strength MS mediumdevoid of plant growth regulators and maximum rooting percentage (75%) in 1.0 mg/l IBA without intervening callus phase.

Chinnaraj and Malimuthu (2011) found that E.tereticornis clone perform well during initiation, elongation and hardening. On the otherhand, E. urograndis found to perform well during multiplication and gave maximum number of shoots per clump. All the Eucalyptus clones found to perform well during the rooting. *E. urograndis* produced a greater number of cuttings per plant per month followed by *E.tereticornis* and *E. camaldulensis*.

Stape *et al*. (2004) revealed that all biometric variables did not differ initially in rainfed and irrigated condition at age 3.1whereas at 5.4 years, significant differences was reported in all growth parameters as well as biomass and volume.

Poor and Rafiei (2013) stated that an application of compost increased leaf area (135 cm^2pot^{-1}), dry weight(19 g pot^{-1}), plant height (51 cm), number of branches per plant (4.4) and number of leaves per plant (10.1). However, as drought increased the all growth parameters were decreased.

Costa *et al*. (2012) stated that DBH of Eucalyptus camaldulensisincreased as the dose of nitrogen, phosphorus and potassium increased.

Mohan and Manokaran (2013) found a total of 17 different clones had leaf spot disease symptoms. Among different clones, the clones of 19 and 52 had severe disease incidence and clone of 4, 17, 188 and 270 had medium level of incidence. The remaining 11 clones had low level of disease incidence.

Kulkarni (2010) screened the Eucalyptus species and clones against Batocera and noted that out of 135 clones, 61 were not affected, 52 less affected, 20 moderately affected and one (71) was fully affected. Clone ITC BCM 2070 was severely damaged resulting in retarded growth in plantations and remained stunted with bushy appearance. However, *E. citriodora, E. torelliana, E. alba, E. urophylla* and *E. pellita* were free from the attack. He further compared Eucalyptus productivity vs. Batocerainfestation and revealed that the irrespective of low or high productivity the infestation was found with varying intensities.

Senthilkumar *et al*. (2013) studied dispersion pattern of Eucalyptus gall wasp in different agro-climatic zones of Tamil Nadu and reported that highest number of clones were infested in North Eastern Zone followed by Southern Zone and Cauvery Delta Zone, a few number of clones were affected in North western Zone and infestation in Western Zone was negligible.

Ekta Sangode (2010) stated that the percent survival of Eucalyptus seedlings in treated plot was 74.45 %, whereas in untreated plot, it was 30.28 %. The avoidable crop loss on survival basis over control in seedlings was 59.33 %. She further observed that percent survival on damage level in treated plot was 34.50 %, whereas in untreated plot, it was 19.34 %. The avoidable crop loss on survival basis over control was found 43.94 %.

Prachi Gangwar *et al*. (2015) found that the clonal plantation of A.P.10 at an age of 3 years showed an average diameter of 11cm, while in CTA (Clonal Testing Area) showed an average diameter of 7 cm. K28 and K25 showed an average diameter of 8 cm and 7cm respectively, in plantation area. Thedifferences for height between various clones for different areas were not very significant.The significant differences between clones were observed for per tree volume. K28 showed maximum variation in per treevolume.

Behera *et al*. (2016) reported that form quotient value rangedfrom 0.58 to 0.71 among 20 clones, where clones suchas C12 and C20 exhibited more of cylindrical boleform having FQ value > 0.70. However, other 16 remaining clones showed FQ values > 0.60. Volume of standing tree varied between 0.12 m3 and0.28 m3. Clones such as C12, C17, C4 and C8 showedbetter performance as compared to other clones for volume.

Poor and Rafiei (2013) stated that an application of manure increased essential oil percentage (1.7 %) and yield of essential oil (303). Moreover, as drought increased the yield of essential oil was decreased.

Ram *et al*. (2011) revealed that the average rate of transpiration in E. tereticornistrees ranged from 44.5 to 56.3 in May, 30.5 to 34.0 in July, 24.1 to 28.3 in October, and 14.8 to 16.2 l day–1 tree–1 in January. The overall average rate of transpiration in the 5-yr-old E. tereticorniswas 30.9 l $day^{-1}tree^{-1}$, which was 268 mm $annum^{-1}$ by 240 trees ha^{-1} against the mean annual rainfall of 212 mm. It clearly indicated that the discharge of groundwater by the strip-plantations of clonal *E. tereticornis* was 1.3 times more than the recharge by rainfall resulting in reclamation of waterlogged areas.

Kumar *et al*. (2018) in their study stated that the eucalyptus farmershad Rs.39,916/acre Gross returns for year fallowed by Rs.33,150/acre net returns and Rs 6766/acre for cost of cultivationper year. They further found the reasons for changing the cropping pattern to Eucalyptus cultivation to the farmers in the district Khammam.Ranks were allotted to thefarmers based on their expression. The reasons expressed were non-availability of labour at critical period of crop 1st (91.53%) followed by high labour cost (73.84%), damagecaused by animals / others (monkeys) (63.84%), high cost ofcultivation for raising of commercial crops (60.76%), rainfed situation (58.46%), crop (eucalyptus) suitable fordifferent types lands (49.23%), availability of marketfacilities and attractive market price for eucalyptus (43.07%), more pest and disease attack for commercial crops (36.92%), Market rate fluctuations different crops (26.15%), flood situation (21.53%), land (Assigned lands) problems (17.69 %), non-availability of electricity facilities (9.21%) followed by non-availability of irrigation water (6.15%), respectively.

Conclusion

The germination percentage and growth parameters of Eucalyptus spp. increased by coir pith based medium. Heavy metals such as Cd and Pb having inhibitory effect on germination. The hardwood cuttings treated with IBA@ 4000 ppm increased survival percentage however in case of water culture, cross Ec 7 X Et 88 treated with 100 ppm IBA also increased rooting percentage and other root parameters. MS medium supplemented with 1.0 mg/l BAP + 1.0 mg/l NAA increased multiplication; ½ strength MS medium devoid of PGRs increased elongation and 1.0 mg/l IBA increased rooting percentage. Increased doses of N, P and K increased DBH; clone P 2045 showed higher value of Form Quotient and Volume. Clone ITC BCM 2070 was severely damaged by Batocera whereas Eucalyptus species (*E. citriodora, E. torelliana, E. alba, E. urophylla* and *E. pellita*) were free from attack. Moreover, treated Eucalyptus eedlings noted higher survival against gall infestation. An application of compost increased growth parameters

while application of manure increased essential oil yield. Eucalyptus is also used for bio drainage in water lodged area. The cultivation of Eucalyptus provides ₹ 33, 150 per acre. Non-availability of labourat critical period of crop is the most probable reason for changing the cropping pattern to Eucalyptus plantation.

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Seminar No. 7

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USE OF ORGANIC MANURES FOR PRODUCTION OF QUALITY TREE SEEDLINGS

Introduction

Manures are the materials which are organic in origin, bulky and concentrated in nature and capable of supplying plant nutrients and improving soil physical environment having no definite chemical composition with low analytical value produced from animal, plant and other organic wastes and byproducts. Rapid use of inorganic fertilizers may cause exhaustion of soil nutrients reserves which leads to loss of productivity and fertility of soil. Adding of Organic Manure (OM) induces life and promotes biological activities in soil, further OM is generally a full appreciation as it improves physical, chemical as well as biological activities. Organic manure commonly used to improve soil conditions and fertility includes Farm Yard Manure (FYM), animal wastes, vermicompost, green manures, crop residues, wastes and oil cakes etc. (Chandra, 2005).

The major problem among the forest based nurseries are poor growth and establishment of seedlings in the nursery as well as when planted outside. A way out can be using of proper organic manures with an efficient and non-polluting good potting mixture in nursery which offers a plant with a substratum for its stability, good nutrient supply, proper water and aeration for roots etc.

Review of literature

Navamaniraj *et al*. (2008) studied the influence of organic manure (OC) on quality seedling production in Bixa orellana and found that media comprising soil, sand and vermicompost (2:1:1) enhanced the seedling growth and yield characteristics compared with other treatments.

Surywanshi *et al.* (2013) studied organic manure based potting mixture for quality seedling production in Oroxylum indicum (L.) Vent. and noticedmaximum in most of parameters

of seedling growth, biomass and seedling quality indices in potting mixture containing soil, sand and vermicompost in the ratio of 2:1:1/2.

Patel and Suresh (2018) observed the effect of fertilizers and manures on quality seedling production of Swietenia macrophylla King. at 120 DAT (Day After imposing Treatment) and found that the treatment T9 (the application of 1g of each NPK with vermicompost (50 g) and azophos (5 g) seedling-1) performed significantly better in growth parameters i.e. shoot length (53.47 cm), root length (39.71 cm), collar diameter (3.63 mm), number of leaflets (27.1), quality indices i.e. volume index (7.03 cm3) and quality index (0.2661).

Sankanur and Shivanna (2010) studied the effect of integrated nutrient management on growth and development of the Pterocarpus santalinus seedlings and found the treatment with 33 g of poultry manure per seedlings showed significantly maximum seedling height, collar diameter, number of leaves, total fresh weight and total dry weight (42.50 cm, 4.92 mm, 18.45, 11.26 g and 4.23 g, respectively). Maximum root length (38.39 cm) was also recorded for the application of 5 g Phosphobacteria.

Khaple *et al*. (2012) studied the influence of growing media on Grevillea robusta seedlings at nursery stage and found the collar diameter, plant height and biomass production of G. robusta was positively influenced by organic manures with the application of goat manure followed by pig manure and vermicompost with increase of doses.

Attri *et al*. (2011) studied the effect of organic manure doses on growth and development of Sapindus mukorossi and noticed that among different organic manure doses treatment, vermicompost @ 10 t/ha recorded significantly higher shoot length, root length, seedling height, collar diameter, number of lateral roots, dry shoot weight, dry root weight and total dry weight (26.44 cm, 17.46 cm, 43.91cm, 4.50 mm, 57.67, 3.29 g, 1.10 g and 4.38 g, respectively). On the other hand various growth attributes were recorded minimum in control i.e. no manure during the experiment.

Biradar *et al*. (1999) studied the effect of vermicompost on growth and vigour of neem seedlings and found that the presence of vermicompost facilitated better collar girth (0.51cm), root length (34 cm), shoot length (37.7 cm), Leaf area(103.3 cm^2) and root shoot ratio (0.90).

Nasir and Wani (2014) investigated the effect of different media on morphological and biomass traits on G48 clone of poplar and observedthat treatment Soil: Sand: FYM 1:1:1 which showed better results in survival percentage, root length, root shoot ratio, total biomass,sturdiness quotient and Dickson quality index compared to other treatments. Hence it was concluded that combination of Soil: Sand: FYM (1:1:1) can be recommended to obtain best growth and development for poplar cuttings.

Kumar *et al*. (2014) observed the influence of de-oiled seed cakes on seedling performance of Dalbergia latifoila Roxb. at 150 DAT. The seedling height (16.33 cm), collar diameter (0.36 cm), root length (4.74 cm), number of root nodules (23.33), leaflets per plant (47.17), root shoot ratio (0.30) anddry weight (5.66 g) were observed in the potting medium containing neem cake with soil and sand mixture (T2M2).

Saini (2019) studied the influence of different organic manures on growth parameters of S. macrophylla at 180 DAT in nursery stage and found that combination of red soil and poultry manure (2:1) treatment produced maximum shoot length (48.66 cm), collar diameter (6.68 mm), number of leaves per plant (35.36) and root shoot ratio (0.32) whereas seedling quality index (0.90) was found maximum in red soil and vermicompost (2:1).

Sondarva *et al*. (2018) investigated the influence of various growing media on growth and vigour of Khaya senegalensis in nursery. In this study, vermicompost + red soil (1:1) was recorded significantly maximum shoot length, root length, number of leaves, collar diameter, fresh weight of plant anddry weight of plant whereas treatment of red soil alone showed poor performance.

Bhasotiya and Tandel (2017) studied the influence ofmedia on growth of Ailanthus excels and noted significantly maximum in most of growth parameters in T7 (Soil: Sand: FYM @ 2:1:2) whereas root length was highest in T8 (Soil:Sand:FYM @ 1:2:2).

Naishima *et al*. (2019) studied the effect of organic manure application on the early growth of Eucalyptus camaldulensis seedlings and noticed that poultry droppings gave the highest plant height, number of leaves, stem diameter (girth) followed by the mixture of poultry droppings and cow dung while top soil (control) recorded the lowest growth. Mixture of poultry droppings and cow dung produced the maximum leaf length, compared to poultry droppings, cow dung and the control, respectively.

Similar kind of research works were carried out by Saka *et al*. (2016) in Khaya sengelensis; Ekpo and Nya (2012) in Delonix regia, Bahunia spp. and Cassia siamea; Imoro *et al*. (2012) in Moringa oleifera and Okunomo (2010) in Parkia bicolor for production of quality tree seedlings by using organic manures.

Islam *et al*. (2019) studied the effect of container and potting media on raising quality seedlings of Acacia auriculiformis in nursery and noticed that the maximum shoot length and nodule number in T5 and maximum root length, collar diameter in T3. The maximum fresh and dry weight of shoot, biomass and shoot:root ratio in T5 and maximum fresh and dry weight of root and quality index in T3.

Conclusion

Study concluded that different growing media plays a vital role for the production of quality tree seedlings in nursery. Organic manure based growing media such as FYM, vermicompost, poultry manure, deoiled cake etc. enhance the growth and vigour of the tree seedlings. Furthermore, the organic manures are also more beneficial and ecofreindly in nature. Review shows that organic manures are useful for enhancing the growth parameters of seedlings (plant height, collar diameter, number of leaves, fresh and dry biomass etc.) and vigour indices (root: shoot ratio, sturdiness quotient, seedling vigour index) as compared to other media. Therefore, organic manures as growing media can be utilized regularly to produce quality tree seedlings in the forest nursery.

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Seminar No. 8

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STATUS OF IMPROVEMENT RESEARCH IN GMELINA ARBOREA

Introduction

Wood, with its unparalleled versatility, is a fabulous gift of nature. It has played an important role in the progress of human civilization and having a wide range of applications. The

demand of wood and wood based products has continuously increased and is likely to increase further in the future. The comparison of actual production and consumption shows that growth in consumption of most of the forest products is higher than production creating demand-supply imbalances. This demand and supply gap of forest products, resulting in exploitation of forest to beyond its carrying capacity (Aggarwal et al., 2009). Plantations as a viable alternative can increase the productivity and contribute substantially in narrowing the gap between demand and supply along with decreasing the pressure on natural forest. However, poor quality planting material is major constraint to performance of plantations (Anon., 2019). Tree improvement aims at producing trees with better features like, higher resistance, quality enhancement, productivity, product uniformity, reduce costsof cultivation, etc. There is a wide variety of species used in plantation, the most common species are Pines, Acacias, Eucalypts spp., Teak, Poplar, Gmelina, Casuarina, Dalbergia spp., Mahogany, Subabul, etc. Among them, Gmelina is one of the candidate trees recommended for large scale plantation programs such as agroforestry, social forestry and urban forestry systems.

Gmelina arborea Roxb. Belonging to the family Verbenaceae, is very promising species for tree planters due to ease of establishment, rapid early growth, expectations of early returns and promising wood characteristics, including high durability and good yield etc. These properties make G. arborea a multipurpose tree for a variety of uses like furniture, plywood, particle board, agricultural equipments, carving, musical instruments, firewood, paper pulp, medicines, fodder, etc. It is nowadays widely accepted species as exotics, to outside its natural range.

For laying out future tree improvement strategy for any species, knowledge of existing efforts made so far is most important. Considering this fact, the present seminar has been prepared to acquire consolidate knowledge about the status of tree improvement research in G. arborea.

Brief review on Research work

Hodge and Dvorak (2003) carried a study on the international provenance collection of CAMCORE. The collection included provenances from indigenous distribution of Gmelia including Thialand, India and Myanmar. They estimated single site genetic parameter for height, DBH and volume consecutively for three years. At all ages, single-site heritability estimates for height, DBH, and volume were moderately low, around h2b=0.10. Heritability for height increased slightly with age, (h2b=0.12 at age 1 to h2b=0.15 at age 3). However, heritability for DBH and volume remained relatively constant across ages. Strong age–age additive genetic correlations were found for all growth traits and all age combinations. Very high heritability associated with series 01, containing provenances no. 1-3 from Thailand: h2b=0.13-0.17, compared to 0.07–0.12 for series 04 and 05 containing provenances primarily from Myanmar, along with some Indian provenances. Family differences were much greater in series 01 than other series. They further observed that provenance variation in series 03 (northern and northeastern India) was estimated to be quite large p2b=0.55-0.60.

Osorio (2003) conducted provenance trial using seed source from 4 countries including Thaialand, Colombia, Costa Rica and Myanmar and established trial at 3 different sites of Colombia. Three-year assessments were made of total tree height, DBH, forking and over bark volume of individual trees. Average survival was very high at all tests and only one Thailand provenance showed below average survival (89%) at the Guachicona site. The best provenances in total volume per hectare were Chantaburi (Thailand), Sin Thaut (Myanmar) and Moeswe (Myanmar) at Guachicona (01G), Vanessa (02A1) and La Estancia (04A), respectively. The control lot from the Ston Forestal seed orchard was superior to the local SCC land race and the unimproved provenances for all growth traits.

Soosai *et al*. (2017) evaluated 15 selected half-sib families were, 10 half-sib families from Tamil Nadu and five from Kerala. The plant height, GBH and volume index varied significantly among the half-sib families. The TSYYG-3 half-sib family recorded the higher plant height (4.81m), GBH (11.34 cm) in KEAMG and volume index (0.053) in KEKBG and KEAVG. Whereas, the lower plant height (2.61m), GBH (7.91cm) and volume index (0.017) was recorded in TTKCD. The 15 half-sib families were formed seven clusters. The maximum half-sib families grouped in to cluster I and III. The maximum intra-cluster value was recorded for cluster VI (24.78). The higher inter-cluster values were recorded between clusters III and VII (40.04). The highest value for plant height was recorded in cluster VII (4.813 m). However, maximum GBH (11.347 cm) and volume index (0.053) was observed in cluster II. Tree height and GBH recorded a high heritability (0.99) followed by volume index (0.86).

Indira (2006) established progeny trial at Chempankolly and Kariamuriam area with eight provenances. Significant differences between provenances for clear bole percentage and tapering at both localities, Khasi Hills showed outstanding performance. Heritability was moderate for clear bole percentage (54.6) and mode of branching (51.4) and high for tapering (72) at Chempankally. She observed high heritability for clear bole percentage at Kariamuriam and all the others characters heritability was low. She clustered the provenances based on clear bole percentage and tapering into three different clusters in both localities.

Wijoyo (2001) conducts a progeny test consist of 60 open-pollinated families. Individual tree was ranked based on percent gain. Average genetic gain for single-test (29.07%) ranged from 5.04 to 39.8%. However, the 30 trees selected from the multiple test estimated an average genetic gain of 39% over the general mean. This gain was 10% higher than the results from a single-site selection in Indonesia.

Kumar (2007) conducted clonal trial including 70 clones collected from different states of India. They observed significant differences for growth traits. They assessed the top twenty clones in terms of mean height for their ranking at the age of 12, 18 and 24 months. 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. Estimation of broad sense heritability for various characters showed moderate heritability for height (0.31), DGL (0.44) and DBH (0.37). The maximum genetic gain (30.2%) was observed for DBH.

In an open-pollinated progeny trial of G. arborea, Lokmal (1994) observed higher narrow sense heritability (h2) values for total height as compare to diameter at 1, 5 and 6 year of age. The consistency of heritability value observed between 5 and 6 year age. They observed higher age-age correlation for height and diameter between 5 and 6 year age.

Sankanur *et al*. (2019) estimated genetic parameters for drupe, kernel, and germination attributes in 40 open pollinated families of G. arborea. Higher heritability value was recorded for seed weight (99.98), while lower heritability was noticed in fruit weight (73.07). Genetic gain for fruit length (39.66) was highest, whereas minimum genetic gain was observed kernel length (13.85).

Rinkuben (2018) evaluated tree to tree variations among 37 mother tees for growth, biomass and vigor. Maximum heritability value (0.99) was recorded for fresh leaves weight, fresh total weight, dry shoot weight and dry leaves weight, whereas minimum for sturdiness quotient (0.45). Maximum genetic gain obtained in dry leaves weight (195.30) as compared to other parameters.

Using ISSR marker, Naik *et al*. (2009) analyzed genetic diversity of G. arborea from eight different regions, including six from three Indian states. The coefficient of genetic differentiation (GST) between populations was 0.6 and the overall level of inferred gene flow (Nm) was estimated 0.34 individuals per generation. Among the different groups, GST varied from 0.24 in the natural forests to 0.64 in plantations. A lower estimate of gene flow (Nm) was also observed in the plantations (0.27) as compared to that in natural forests (1.52). The AMOVA analysis showed that 59% of the total variance occurred among populations and only 41% resided within populations

Wee *et al*. (2012) analyzed genetic diversity of G. arborea in 534 samples representing 19 natural populations from India, China, Thailand and Myanmar. Genetic diversity parameters were compared among populations observed heterozygosity (Ho) for all populations was 0.60, with the highest values from Amboli (India, 0.67) and the lowest Ho values were from ManNa (China, 0.42). The mean number of alleles per locus for all 19 populations was 5.96, ranging from 3.70 (Chessa) to 9.60 (Kassa). On the other hand, 17 out of 19 populations had positive fixation index ranging from 0.02 to 0.19.

Conclusion

In conclusion, despite immense importance of the species, a very little effort has been directed toward the tree improvement work in G. arborea. Only a few trials on provenance variation and tree to tree variation study are available. Overall, the heritability of height and diameter were found moderately low. The studies also suggested that selection and estimation of genetic parameters are more reliable in older age at least above three years. Interesting fact revealed by present studies are that the most of populations are fragmented and in patches, hence the limited gene flow is taking place. This information can be effectively utilized for provenance demarcation and collection of planting material.

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Seminar No. 9

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VARIATION IN CHEMICAL PROPERTIES OF WOOD IN SHORT ROTATION TREE SPECIES

Introduction

Pulp is a lignocellulosic fibrous material prepared by chemically or mechanically separating cellulose fibres from wood, fiber crops, waste paper, or rags.Variation inchemical properties of wood such as cellulose, hemicellulose, lignin and extractivesinshort rotation tree species play important role in pulp production. Among chemical properties the quality and quantity of pulp and paper dependsespecially on high amount of holocellulose (cellulose + hemicellulose) and less amount oflignin,extractives (cold water, hot water, and alcohol benzene solubility and 1% NaOH solubility) and ash content in wood.Hardwood and softwood tree species are used in pulp and paper making. Generally paper made from hardwood tree species are used for printings and writings purposes whereas, softwood species are mainly used for packaging.

During the year 2017-2018, the per capita paper consumption in Indiawas over 13 kg, behind the global average of 57 kg. The domestic demand in India grew from 9.3 million tonnes in 2007-2008 to 17 million tonnes in 2016-2017 at an annualgrowth rate of 6.9% (Sabnavis et al., 2018). The Indian pulpand paper products market is projected to grow from $ 8.6 billionin 2018

to $ 13.4 billion by 2024, exhibiting an annualgrowth rate of 7.8% during 2019-2024 (Anonymous, 2019).The projected demand for paper by 2025 is 24 million tonnes with indigenous production of 22 million tonnes leading to a shortfall of 12 million tonnes of wood. (Kulkarni, 2013)

Therefore, there is a tremendous scope to select more number of short rotation tree species based on the chemical properties of wood for highpulp production to bridge the growing gap between demand and supply of pulp wood.

Brief review of research work

Jahan *et al.* (2008) comparedthe chemical parameters of 10 years old Acacia auriculiformis with Acacia mangiumat Dhaka, Bangladesh and reported thatholocellulose content (76.1%), pentosan content (17.5%) and ash content (0.6%) in *A. auriculiformis* was higher than *A. mangium*, whilelignin content was lower (19.4%) than *A. mangium* (25.6%).In the investigation, they found that alpha-cellulose (44.1%) in *A. auriculiformis* was lower than *A. mangium*. Total extractive content such as cold water, hot water and 1% NaOH solubilities of *A. auriculiformis* was higher than *A. mangium*. They concluded that the alpha-cellulose of A.auriculiformis was lower and extractive content was higher as compared to *A. mangium*. Hence, the pulp produced from *A. auriculiformis* can be used in the production of writing and printing quality paper.

Yahya *et al*. (2010) studied the chemical compositionof 7-year-old *Acacia hybrid* and its parents (*A. auriculiformis* and *A. mangium*) at Kyoto, Japanand found that holocellulose content (82.88%) of Acacia hybridwas higher than its parents, whereaslignin content (30.91%)and alcohol-benzene extractives (2.9%) were lower than its parents. The α-cellulose content (45.45%) of the *A. hybrid* was higher than *A. auriculiformis* (40.57%) and comparable to A. mangium (45.71%). They revealed that the high holocellulose and α-cellulose contentof A. hybrid can be expected to produce higher pulp yield and strong paper.

Dutt and Tyagi (2011) investigated on the chemical characteristics of wood from 11 species of 4 years old Eucalyptus from IIT, Roorkee. They reported thatholocellulose content (67.8%) of E. 413 (hybrid) washigher and Klasonlignin content (25.9%) was lower than other species of Eucalyptus.The alcohol benzene solubility (2.50%) and ash content (0.36%) of E.albawas lowest among other Eucalyptus species. However, the pentosan content (18.66) of E. grandis was higher than other Eucalyptus species. They concluded that the chemical analysis of Eucalyptus species reveal satisfactory levels of holocellulose (except E.camaldulensis) and lignin content (<30%) exceptE.camaldulensis and E. grandis.

Malik *et al*. (2003) studied on chemical properties of 4-5 years old *Leucaena leucocephala* at Saharanpur and recorded that holocellulose content (76.58%) and α-cellulose content (58.70%) of *L. leucocephala* was higher than Eucalyptus species and lignin content was lowest (19.55%). However, the pentosan content and different extractive contents were comparable to *Eucalyptus* species. Ash content was slightly higher (0.85%) than *Eucalyptus*

species. They concluded that due to high holocellulose and α-cellulose content and low lignin content with xylan type of hemicellulose L. leucocephala can be directly utilized for good quality and high pulp yield with shorter cooking cycle and chemical dosing.

Ferreira *et al*. (2013) compared the chemical properties of 12-year-old Ailanthus altissima with Eucalyptus globules at Coimbra, Portugal.They reported that cellulose content (49.7%) of *A. altissima* was higher than *Eucalyptus globules* (45.5%), while lignin content (23.6%) was low. Other chemical properties such as hemicellulose, extractive and ash contents were found comparable to the *Eucalyptus globules*. Hence, A. altissima has a good potential to be used as a partial substitute of the main raw material for pulp industry.

Saravanan *et al*. (2013) studied the chemical composition of *Melia dubia* wood samples at one to five age gradationsfrom Tamil Nadu, India. They recorded that holocellulose content (75.50%) was highest at first year. On the contrary, pentosan content (16.20) and ash content (0.5%) were highest at fifth year. Extractive contents such as cold water, hot water, alcohol-benzene and 1% NaOH solubilities were lowest at first year and highest at fifth year. Their results indicated that younger age trees of *M. dubia* are also suitable for paper industry considering high holocellulose, low lignin content at low strength of pulp and paper. However, five years old *M. dubia* is suitable for high strength of pulp and paper.

Jahan *et al*. (2015) compared thechemical characteristics of *Trema orientalis* with Bamboo chips in Dhaka, Bangladesh.They found that alpha-cellulose content in *T. orientalis* (49.1%) was higher than bamboo (45.2%). However, it was reported that lignin content (24.1%), pentosan content (23.5%) and ash content (1.1%) in *T. orientals* were lower than Bamboo. Hence, the results indicated that *T. orientalis* can provide insight better pulp yield than bamboo.

Deepika *et al*. (2019) analyzed the chemical properties of 4, 5 and 6-year old *M. dubia* at Saharanpur, India. They revealed that 5-year-old *M. dubia* exhibited the lowest ash (0.65%) and alcohol benzene extractives (1.756%) while the highest holocellulose (82.55%) and pentosans (16.60%). The result confirmed that among all three harvesting ages of *M. dubia*, the five years was rated as the best age for pulp and paper.

Azeez *et al*. (2016) compared the chemical characteristics of 12 years old trunks of *Gmelina arborea* and *Bambusa vulgaris* measuring 4.5 cm in diameter from Nigeria.They reported cellulose contents of 51.25 % and 48.88% and Klason lignin of 29.05% and 27.21% in extractive-free dry biomass of *G. arborea* and *Bambusa vulgaris*, respectively. The hemicellulose content of *B. vulgaris* was slightly higher than *G. arborea*. They concluded that the chemical composition of *G. arborea* and *B. vulgaris* are fairly similar and both species can be used in combination for producing high quality pulp and paper.

Samariha and Kiaei (2011) compared the chemical composition ofwood instem and branches of 6 to 7 years old *Ailanthus altissima* in Iran. They recorded that cellulose (47.18%) and lignin content (25.19%) in *A.altissima* were sparingly higher in stem than branches of *A. altissima*. However, alcohol-benzene extractive (3.5%) was slightly higher in stem and ash content (1.75%) was slightly higher in branch. The result suggested that stem and branch wood of *A. altissima* can be a potential source of good pulp yield.

Sinha *et al.* (2019) studied the chemical properties of *M. dubia* at one to five age gradations at Navsari Agricultural University, Gujarat. They reported that cellulose content of *M. dubia* was lowest in first year (35.06%) and highest in fifth year (49.96%) and it was found at par in fourth (49.48%) and fifth year (49.96%). The low Klason lignin content was reported in first year (24.41%) and high lignin contents were recorded at fourth and fifth year (30.85% and 31.34%, respectively). The result revealed that 4 to 5 year old trees of *M. dubia* are highly suitable for paper industries considering the high cellulose content rather than high lignin content.

Chavan *et al*. (2015) studied the chemical characteristics of 4-5 years old *Leucaena leucocephala* and compared with *Eucalyptus hybrid* and *Casuarina equisetifolia* at Mettupalayam, Tamilnadu. They recorded high holocellulose content (75.5%) and low lignin content (20.40%) in L. leucocephala in comparison to *E. hybrid* and *C. equisetifolia*. The total extractive content (hot water, 1% NaOH and alcohol-benzene solubilities) of *L. leucocephala* was similar to *E. hybrid* and *C. equisetifolia*, whereas ash content was comparatively high (0.6%). They concluded that pulping quality of *L. leucocephala* is superior over traditional pulpwood species.

Bharathi *et al*. (2017) analysed the chemical properties of 3-5 years old alternate pulpwood tree species viz., *Albizzia lebbeck*, *Cassia siamea*, *Dalbergia sissoo*, *Anthocephalus cadamba*, *Melia dubia*, *Acacia auriculiformis*, *Leucaena leucocephala*, *Gmelina arborea*, *Eucalyptus tereticornis* at Ballarpur Industries Limited in Mumbai. They reported that the holocellulose content ranged between 68.8 % (*A. cadamba*) and 73.7% (*M. dubia*) and other species recorded in between these. The lignin content in all nine species was recorded less than 30 per cent. The total extractive content was lowest (18%) in *L. leucocephala* and highest in *C. siamea* (27.1%). The ash content was lowest (0.5%) in *A. lebbeck* and *L. leucocephala*, however, it was highest (0.95%) in *A. auriculiformis*. They revealed that *M. dubia* is most superior among eight species followed by *L. leucocephala*, *D. sissoo*, *G. arborea* along with *A. lebbeck* and *A. auriculiformis*.

Conclusion

The chemical properties of wood such as holocellulose, cellulose, pentosan (xylan), extractives (cold water, hot water, 1% NaOH and alcohol-benzene solubilities) and ash content varied among different short rotation tree species. The selection of tree species on the basisof high holocellulose, pentosan and cellulose contents and low lignin, extractives and ash contents is important for good quality and high pulp yield. Among several short rotation tree species discussed, *M. dubia*, *L. leucocephala*, *Acacia hybrid*, *A. mangium*, *A. auriculiformis*, *G. arborea*, *D. sissoo* and *A. lebbeck* are promising alternate tree species for high pulp yield over traditional tree species like Eucalyptus and Casuarina. Moreover, there is a need to explore more number of short rotation tree speciesbased on high pulp yield.

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Seminar No. 10

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Degree: M.Sc. Forestry (Forest products & Utilization)	**Course No:** FOR 591
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Minor Advisor: Dr. A. A. Mehta	**Date:** 04/01/2020

ETHNOBOTANICAL STUDIES OF NORTH EAST INDIA

Introduction

The term Ethnobotany was first coined by John William Harshberger in 1896. Jain Father of Indian Ethnobotany 1981) defined it to be the relationship between human society and plants. Ethnobotanical knowledge provides information regarding the traditional uses of plants which are used by tribals for both medicinal and non-medicinal purposes. It throws light upon the past distribution of plants. It helps us to understand as to what were the then existing ancient trade routes. Ethnobotany/ Ethnobiology is now a multidisciplinary studies comprising of allied branches like Ethnotaxonomy, Ethnomedicines, Ethnoforestry, Ethnoveterinary medicines,

Ethnoecology, Ethnoagriculture and Ethnogastrology. Applied aspects of Ethnobotanical research includes Ethno pharmacology, Traditional phytochemistry and validation of Ethnobotanical claims (Jain, 1981). Some important organization involved in Ethnobotanical research are: NEHU University, BSI Shillong, BSI Kolkata, BSI Gangtok, Assam and Mizoram University etc.

North East India comprises of the states viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim (Map 1) and lies between 21°34'N to 29°50'N latitude and 87°32'E to 97°52'E longitude. Total geographical area of 262060 sq. km. The region harbors nearly 50% of the flowering plants recorded from India and exhibits one of the richest floral diversity. The region is home to many wild relatives of cultivated plants such as Orchids, Musa, Bamboos, Citrus, Gingers, Rhododendrons and Palms. More than 250 tribes of different ethnic groups that speak more than 200 dialects with distinct cultural entities resides in the region (Mao and Roy 2016). In context to total floristic diversity enumerated state of Arunachal Pradesh (5000 spp.) is followed by Sikkim, Meghalaya, Assam, Manipur, Nagaland, Mizoram and Tripura with 4500 spp., 3500 spp., 3010 spp., 2500 spp., 2250 spp., 2200 spp. and 1600 spp. respectively. Some of the families such as Nepanthaceae, Illiciaceae and Clethraceae are unique in the world. These families are reported from the South East Asian countries and are represented by a limited number of species like Clethra spp. and Nepenthes khasiana in North East India. (Chakravarty *et al.*, 2012).

The North East Region has its significance due to high level of endemism and endemic spp. In all there are 07 floristic diversity hot-spots viz. Khasia-Jaintia hills, Patkoi-Manipur-Lushai hills, Assam, Arunachal Pradesh Himalaya, Sikkim Himalaya, Eastern Himalaya Plant gene pool and Khasi Jaintia-Lushai Plant gene pool (Nayar, 1996). AICRPE (2002) has also focused on rich ethnic diversity of NER. 10 major tribes of NER are Bodo, Khasi and Garo with population of 2.0 million, 0.63 million and 0.45 million followed by Kachari, Naga, Boro Kachari, Mikir, Ao, Adi and Lepcha. State of Assam has maximum 79 ethnic groups/ tribes, followed by Mizoram (72 tribes), Nagaland (53 tribes), Arunachal Pradesh (36 tribes), Manipur (30 tribes), Meghalaya (22 tribes), Tripura (19 tribes) and least in the state of Sikkim (03 tribes) respectively. The state of Meghalaya has highest no. of Ethno botanically used spp. (650) followed by Manipur (556 spp.), Nagaland (526 spp.) Sikkim (508 spp.), Arunachal Pradesh (307 spp.), Assam (286 spp.), Mizoram (238 spp.) and Tripura (194 spp.) respectively (Thakur et al, 2018). Nayar (1996) also reported 04 species viz. Coptis teeta Wall., Musa sikkimensis Kurz., Piper muneyporense C. DC. and Pueraria bella Prain. which are cultivated and consumed by Mishmi, Lepcha and Adi tribes of Assam, Arunachal Pradesh, Sikkim and Manipur states of NER. Arora (1997) reported 3 plant spp. *Flemingia vestita* L., *Digitaria cruciata* L. var. esculenta and Coix lacryma-jobi L. which are cultivated only by tribes of Khasi and Jaintia hills.

Brief review of research work

Arora (1997) documented the total number of 132 species used by tribes are located in NER. Fruits (51 spp.) are utilized maximum. Similarly total of 320 wild edible plants are found

distributed in Eastern Himalaya and NER. Again (168 spp.)- fruits are consumed for edible purposes followed by green leafy vegetables (86 spp.).

Saklani and Jain (1994) conducted cross cultural ethnobotanical studies of NER and reported 1226 ethnobotanically important spp. out of 1296 spp., 773 spp. are used as medicines, 610 spp. as food and 363 spp. for material purposes. Out of 12 tribes studied, Jaintia tribe uses maximum (238 spp) for ethnobotanical purpose, followed by Naga tribe (235 spp.), Khasi (229 spp.) and least 60 spp. used by Boro tribe in NER.

Mao and Roy (2016) have provided synoptical review of total publications w.r.t. ethnobotany of NER. In all 470 publications are available, out of which are 402 (85.53 %) are research articles. Maximum publications (89) is on general ethnobotany followed by 84 publications on wild foods. State of Assam (37 %) has maximum publications, followed by Manipur (12 %), Meghalaya and Arunachal Pradesh (11 %) and Sikkim (10 %). Further, in context to different research aspects of research work/ publication, the state of Assam contribute maximum. General ethnobotany (23 publications), Wild foods (32 %), Ethnoveterinary uses (3 publications), Ethnomedicine (84 Publications), Religious and Supernatural (5 publications). The state of Assam also contributed maximum in Herbal dye and Local dyes.

Chhetri *et al*. (1992) enumerated the ichthyotoxic plants of NE India. They concluded that the maximum number plant part used for ichthyotoxic activity are leaves (23 %), followed by whole plant (22 %) and bark (21 %). Out of 33 spp. reported for the fish poisoning maximum 27 spp. is used by Khasi tribe. 4 spp. by Jaintia and 2 spp. by Garo tribe.

Shukla and Montanari (2018) studied various Traditional mode of preparations employed by the tribes of NER like Decoction, juice Infusion, Powder and Pest. They concluded that maximum preparation is in decoction (65 %). Decoction is used maximum to overcome cough and cold (13 %) followed by 11 % each as Aphrodisiac and Diarrhoea.

Ramashankar *et al*. (2012) carried out research on Ethnobotanical plants in 8 states of NER to cure five common disease- gynaecological disorders, diabetes, malaria, stomach problems and disease related to child care. Maximum number of plant spp. (47 %) used in state of Manipur for curing five common disease. disease wise usage of plant spp. despite maximum (42 %) species used to cure malaria, followed by 22 % and 21 % each for diabetes and stomach problems. State wise bifurcation of plant species used to treat five common disease by tribes of NER indicated 38 spp. used to cure malaria in Arunachal Pradesh subsequently 8 spp. and 7 spp. to cure stomach problems and malaria in Assam. 78 spp. to cure malaria in Manipur, 8 spp. each to cure stomach problems and disease related to child care in Meghalaya, 10 spp. to cure malaria in Mizoram, 2 spp. cure malaria in Nagaland, 15 spp. cure malaria in Sikkim and 3 spp. to cure stomach problems in Tripura. Authors also looked in to status of traditional healer in NER and procurement of plants by tribes of NER. They concluded that 60 % traditional healers are professionals, 30 % social worker and 10 % those who don't have other alternatives. In context to the age wise breakup of traditional healers 50% belongs to the age group of 40-60 year followed by 30 % in to the age group of 60-80 year and 20% in the age grope of 20-40 year. Also

authors concluded that 60 % of plant are collected form the wild sources, 25 % are collected form the home gardens and 15 % from the crude drug of NER.

Shankar *et al*. (2017) recorded 535 indigenous medicinal plants spp. used by the tribes of NER. Maximum 13% each spp. are used to treat cough and fever respectively, followed by 10% spp. for stomach problems, 8 % spp. each for dysentery, diuretic and skin disease. With respect to utilization of the plant parts a roots of 142 spp. are used for the ethnomedicinal purposes followed by 105 plant spp. where whole plat is used and 100 spp. whose leaves are utilized for ethnomedicinal uses.

Pfoze *et al*. (2014) documented ethnobotanical plants used by one of the major tribe of NER- Naga tribe. Overall 755 spp. are used by Naga tribe out of which 40% are used in ethnomedicine, 21% edible plants, 11% edible fruits, 9% each miscellaneous and dye yielding, least 1% used in fodder and pasture grass. Maximum 43 spp. of Papilionaceae family is used for ethnobotanical purposes. Further, maximum 318 genera and 464 spp. are used in ethnomedicines.

Tushar *et al*. (2010) studied the ethnomedicinal uses of Zingiberaceous plants of Northeast India and concluded that Gastrointestinal conditions (58%) and chest and Antibacterial (41%) related ailments were the main categories for which Zingiberaceous plants are used.

Bhattacharya (2011) investigated ethnobotanical used of 12 Rhododendron spp. which are used by the NER tribes for various purposes. Out of this 12 spp. R. arboretum Sm. is widely used. 5 spp. are used for the medicinal purposes, 4 considered as poisonous and 8 spp are used for non-medicinal purposes.

Chhetry and Belbahri (2009) studied the indigenous pest and disease management practices in traditional farming systems employed by the tribes of NER. Various plant spp. such as Azadirachta indica seed powder, Citronella grass, Lemon grass, peels of pomelo, Bambusa tulda, Dendrocalamus hamiltonii, Zanthoxylum acanthopodium , Artemisia vulgaris, Croton caudatus, Munromia wallichi, Justicia adhatoda, Cymbopogon khasianum and Saccharum spontaneum are used to manage disease and pest.

Singh and Gupta (2002) carried out their research in Bamboo based water management system in NER. Bamboo based irrigation system is mainly confined to the tribe of Khasi and Jaintia (Meghalaya), where by 2 dominat spp of bamboo *viz*. Bambusa tulda and Dendrocalmus hameltonii are utilized.

Bhuyan (2015) evaluated comparative study of ethnomedicines among the tribes of NER. Centella asiatica L. is most common spp. used by 8 tribe followed by Oroxylum indicum (L.) Vent is used by 7 tribes, *Houttuynia cordata* Thunb. and *Terminalia chebula* Retz. which is used by 5 tribes and Curcuma longa L. which is used by 4 tribes. Oxalis corniculata L. is only used by Apatani tribes of NER.

Borthakur and Sharma (1994) studied that plant parts used for Ethnoveterinary purposes in Assam. In all 45 spp. reported to have Ethnoveterinary usage. Maximum used plant part used for curing cattle disease are leaves (33 %) followed by stem (21 %), root and seeds (12 % each), fruits (10 %), bark (7 %) and flowers (5 %).

Brahma *et al*. (2015) studied various plants used for making musical instrument by the tribes of NER they mainly used *Bambusa tulda, Alstonia scholaris, Artocarpus heterophyllus, Bambusa pallida, Bambusa assamica,, Mangifera indica, Sterculia villosa* and *Bambusa assamica*.

Cajee (2018) documented dominate bamboo spp. utilized by different tribes by NER. Dendrocalamus hamiltonii is most commonly used in all the 7 states out of 8 states of NER. Maximun spp. used in Assam, 5 spp. are used each in Meghalaya and Mizoram, 4 spp. used in Arunachal Pradesh, 3 spp. each in Manipur and Nagaland, least 2 spp. used each in Sikkim and Tripura. Along with Dendrocalamus hamiltonii and other Dominate bamboo spp. are Bambusa balcooa, Bambusa tulda, Dendrocalamus giganteus, Dendrocalamus strictus and Bambusa vulgaris.

Lalruatfeli *et al*. (2019) documented ethnomedicinal plants grown in home grown by the tribes of Mizoram. They recorded a total 53 ethnomedicinal plants belonging to 51 genera and 29 families. Maximum number of plants from Asteraceae family (25) which is followed by Fabaceae (14), Solanaceae (6).

Amirthalingam (2016) documented sacred groves worship by tribes of NER. Maximum number of sacred groves found in Manipur state (531) which is followed by Arunachal Pradesh (159) and Meghalaya (105).

Das (2014) recorded 47 wild species of mushrooms used by tribes of Sikkim. Out of which 10 species- *Agaricus augustus* Fr., *Auricularia auricula-judae* (Bull.) Quél., *Bulgaria inquinans* (Pers.) Fr., *Cordyceps inilifaris* (L.) Link., *Copriitopsis atraineiitaria* (Bull.) Redhead, *Daedaleopsis confragosa* (Bolton) I. Schriit, *Lycoperdon perlatum* Pers., *Lactarius piperatus* (L.) Pers., *Trametes gibbosa* (Pers.) Fr. and *Xylaria polymorpha* (Pers.) Grev. are used for curing more than five diseases.

Agrawala *et al*. (2014) recorded 50 species of orchids used by tribes of Sikkim. Out of which 10 species- *Acampe papillosa* (Lindl.) Lindl., *Aerides multiflora* Roxb., *Arundina graminifolia* (D. Don.) Hochr., *Cymbidium longifolium* D. Don., *Dendrobium aphyllum* (Roxb.) C.E.C. Fischer, *Gymnadenia orchidis* Lindl., *Liparis odorata* (Wild.) Lindl., *Platanthera sikkimensis* (Hk.f.) Kranzlin., *Satyrium nepalense* D. Don. and *Vanda testacea* (Lindl.) Rchb.f. are used for the curing more than five diseases.

Rai (2016) listed 19 dye yielding plants used by Indo-Burma hot spot region in NER. Out of 19 dye yielding plants maximum 7 spp. yields red colour dye.

Hynmewta and Kumar (2008) recorded a total of 6 plants species that are used by tribe of Meghalaya as an alternative for plastic bags. Out of 6 plants species, *Phrynium pubinerve* is used extensively by Mikir tribe of Meghalaya, 3 plant spp.- *Erythrina arborescens, Areca catechu* and *Musa paradisiaca* are used by Khasis and Jaintia tribes whereas Macaranga denticulate used by Bodo Kachari and Aptani tribe of NER.

Teron (2016) studied the ethnic food plants and foods for NER and reported plants used by various tribes to prepare different food products. Most commonly used plant species is

Glycine max (L.) Merril. That is used by Karbi, Naga, Khasi, Mizo, Garo and Meitei tribes of NER.

Lalramanghinglova (2012) recorded 25 new plant species which are consumed as an emergency food by tribes of Mizoram. In various form like boiled, fried, roasted and eaten raw. Kholia (2014) recorded 54 Species of Pteridophytes used by tribes of Sikkim. Out of 10 species- *Adiantum venustum* D. Don., *Aleuritopteris bicolor* (Roxb.) Fras.-Jenk., *Cyathea chinensis* Copel., *Deparia boryana* (Willd.) M.Kato, *Diplazium javanicum* (Blume) Makino, *Diplazium succulentum* (C. B. Clarke) C. Chr., *Lycopodium japonicum* Thumb., *Lycopodium flexuosum* (L.) Sw., *Pteridium revolutum* (Blume) Nakai and *Tectaria dubia* (C. B. Clarke & Baker) Ching are used for curing more than five disease.

Mao *et al*. (2009) worked on important NTFPs collected by tribes of NER. Potentail economical plant spp. collected by tribes are *Panax* assa*m*icus, *Paris polyphylla*, *Dendrobium denudans*, *D. eriaflorum*, *D.* tran*s*parens, *D. devonianum*, *Cordyceps sinensis* and *Rubia manjith*.

Conclusion

Rich floristic diversity of Orchids, Musa, Bamboos, Citrus, Gingers, Rhododendrons and Palms combined with diverse ethnic group representing more than 250 tribes of India are some of the salient features of North Eastern India. Major tribes inhabiting NER are Bodo, Khasi, Garo, Kachari, Naga, Boro, Mikir, Ao, Adi and Lepcha with the state of Assam having highest ethnic tribes (79 ethnic groups). Similarly, state with least ethnic tribes is Sikkim (3 ethnic groups). State with maximum number of ethnobotanically utilized Plant spp. is Meghalaya (650 spp.), followed by state with least number of ethnobotanically utilized Plant spp.: Tripura (194 spp.). Out of 24560 plant spp. reported from NER, 3265 spp. are ethnobotanically utilized which accounts to 13.29 % utilization of wild plant by the tribes of NER. State with maximum utilized edible plants by tribes of NER is Manipur (523 spp.), subsequently state with least utilized edible plants by tribes of NER is Arunachal Pradesh (232 spp.). Out of 3265 ethnobotanically important spp. recorded for edible purpose, 2807 spp. is edible (85.97 %). This accounts to 11.42 % edible plants out of 24560 total plant spp reported from NER. With respect to state with maximum ethnobotanical publications, Assam contributes maximum with (37 %) and state with least ethnobotanical publications is Tripura (5 %). Sacred groves are prominent feature in tribal life of NER. State with maximum worship scared groves is Manipur (531) whereas state with least worship scared groves is Sikkim (16). Some classical examples of Ethno conservation practices employed by the tribes of NER are cultivation of Coptis teeta Wall., Musa sikkimensis Kurz., Piper muneyporense C. DC., Pueraria bella Prain., Flemingia vestita L., Digitaria cruciata L. var. esculenta and Coix lacryma-jobi DC by Khasi, Jaintia, Mishmi, Lepcha and Adi tribes of NER. Jaintia tribe uses maximum plants for ethnobotanical purpose (238 spp.), followed by Naga (235) and Khasi (229). Some prominent numerical data on ethnobotanical plants used are 33 spp. for fish poisoning, 366 spp. used to cure common diseases, 535 total ethnomedicinal plants reported amongst ten tribes of NER, 1296 ethnobotanically important plants, 34 spp. of Zingiberaceae family, 12 spp. of Rhododendrons, 13 spp. for disease and pest management, 45 spp. for ethnoveternary purposes, 8 spp. for musical instruments, 53 spp. ethnobotanically significance

grown in home garden, 47 spp. of Mushrooms, 50 spp. of orchids, 19 spp. for natural dyes, 6 spp. as a plant wrappers, 14 spp. as ethnic foods, 25 new recorded emergency food plant spp., 54 spp. of Pteridophytes and 8 spp. of NTFPs are reported by various worker in context to ethnobotany, ethnomedicines, ethnogastrology, ethnomycology, ethnomusicology and ethnopteridological aspects. Besides above mention details other aspects such as cross culture and comparative ethnobotanical study, medicinal and non-medical usage of bamboo spp., collection of plants for ethnobotanical uses and socioeconomic status of traditional healers in NER has also been taken into consideration the current presentation delivered.

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Seminar No. 11

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Degree: M.Sc. Forestry (Forest Products & Utilization)	**Course No:** FOR 591
Major Advisor: Dr. L. K. Behera	**Venue**: Room No. 101
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IMPORTANCE OF HOMEGARDENS IN BIODIVERSITY CONSERVATION AND FOOD SECURITY

Introduction

Homegardens are the traditional agroforestry systems where multipurpose trees and shrubs (woody component) aregrown in intimate association with herbaceous species (mainly annual, perennial and seasonal agricultural crops) and/or livestock which all aremanaged within the compounds of individual homes, maintained by members of the household and their products are intended primarily for household consumption (Fernandes and Nair, 1986). It is also called as multi-tier system or multi-tier-cropping (as it consists of different canopy strata),backyard gardens, homestead farms etc. The main function of homegarden is food production and other function includes biodiversity conservation, carbon sequestration, soil conservation etc. The homegardens can be found in almost all tropical and sub-tropical regions. In developing countries such as Bangladesh, Indonesia and Sri Lanka homegardens are the major source of food production, nutrient supplement and contribute towards socio-economic development of farmers.

Review of literature

Ulman *et al*. (2017) reported total of 2357 individuals of potential host trees for nesting of Ploceus philippinus (Baya weaver) belonging to *Areca catechu*, *Cocos nucifera*, *Phoenix sylvasticus* and *Borassus flabellifer*. Trees of *A. catechu* were arranged in block (96.50%) and row pattern (3.5%) whereas other three host trees were arranged in singlepattern. Among 3.5% individuals of *A. catechu* planted in row pattern, 47.5% had nests (complete and helmet stage). The other three host trees had nests in various stages of development but none of them were completed by *P. philippinus*. Thus, *A. catechu* planted in row pattern was the most preferred host tree species for nesting by *P. philippinus* as compared to the other three host tree species in homegarden. The encounter rates of predators (arboreal mammals) and reptiles were higher of 2.56 and 0.59, respectively in block pattern of host tree arrangement.

Singh *et al*. (2016) reported the average production of vegetables (1441 kg), fruits (1050 kg), mushroom (42.5 kg) and other miscellaneous products from the homestead gardens in the two agro-ecolological situations. Further, less than 50 per cent of the produces were consumed by the farmers however vermicompost, poultry manure and goatery manure were used 100 per cent. Also elaborated the contribution of homestead gardens to nutrition security in terms of supply of essential minerals, vitamins and calories. They elaborated the home consumption of vegetable and nutrition supply with total of 230 kg of vegetables consumed by the farmers throughout the year with energy (233,000 kcal), Vitamin A (257,000 µg), Vitamin C (70,400 mg), protein (24,500 mg), calcium (79,300 mg), phosphorus (153,000 mg) and iron(13,100 mg) in a year.

Devi and Das (2013) studied the ecological characteristics of Meitei homegarden Bantarpur village, Assam and found 71 species, 60 genus and 35 families with Shannon Diversity Index of 2.86 and Simpson dominanceindex of 0.11. Further they reported fuelwood

and fruit trees formed the dominant use category followed by timber, vegetable, medicinal etc. which indicate the contribution of Meitei homegarden in the food security of Meitei community.

Saikia *et al*. (2012) recorded the overall concentration of dominance (Simpson's Index) of 0.05 and diversity of tree species (Shannon-Wiener Diversity Index) of 3.53. The average number of species per homegarden did not differ however density of tree species increased with decreasing homegarden size. Further, the occurrence of different plant species in each use category varied among different homegarden categories and the species were mainly used for vegetable, timber, fruit *etc*.

Chadha *et al*. (2012) studied the average daily yield of vegetables for 20 months and found production of Andhra Pradesh (AP), Punjab and Jharkhand homegardens were of 12 months, 9 months and 7 months, respectively to meet the recommended consumption level of 200 g per person. The yield data suggested that the 6x6 m^2 homegarden designs for AP, Punjab and Jharkhand could significantly improve households' access to vegetables and were sufficient to meet the recommended levels in most times of the year. Additionally they confirmed that the average daily nutritional yield from the three different homegarden modelsand reported vitamin A and vitamin C were produced sufficient for AP, Punjab and Jharkhand as compared to Recommended Daily Allowance (RDA) whereas protein and iron were produced less than the RDA in the homegarden model of three states. The nutrient yield data confirmed the 6 x 6 m^2 homegarden supply at recommended vegetable consumption level, vitamin A and vitamin C were sufficient, however protein and iron supplies were difficult to achieve *i.e*. 30% of RDA.
Nongmaithem (2017) surveyed the homegarden system of the Navsari district of south Gujarat. He documented total of 11 tree and 14 agricultural crop species.

Nabi *et al.* (2018) studied the flora of homegarden of Jammu and Kashmir and recorded that the conservation of medicinal plants like *Mentha arvensis*, *Rumex nepalensis*, *Taraxacum officinale etc*. which are in the endangered/vulnerable in IUCN Red Data Book.

Pilania *et al*. (2015) recorded a total of 80 plant species in the homegardens of South Gujarat. Most dominant families were Mimosaceae, Papilionaceae, Caesalpiniaceae, Combretaceae, Moraceae *etc*.

Tynsong and Tiwari (2010) recorded a total of 197 plant species (70 trees, 41 shrubs, 51 herbs, 23 climbers and 13 epiphytes) belong to 77 families comprising of 73 angiosperm, 1 gymnosperm and 3 pteridophytes. Further reportedhigher Shannon Diversity Index for tree (4.01) and shrub (3.11) in Mawariang village whereas it was maximum for herb (3.03), climber (2.49) and epiphyte (1.59) in Nongkwai village. They alsorevealed that the homegardens contribute a great deal offood supply and annual incomethrough the gross production.In the five villages of south Meghalaya, Piper betle contributed maximum of 24.15 % towards gross production.

Mohan *et al*. (2007) recorded maximum mean number of species/garden (38) in large size and commercial homegarden whereas mean species density (number of species/100 m^2), mean tree species density (number of tree species/100 m^2) and mean Margalef index were recordedin small size homegarden of 4.9, 0.7 and 6.42, respectively, while maximum higher mean Shannon-

Wiener index was recorded for large size homegarden of 1.42. They also reported higher agroecological importance value for V, O, M (100) in case of small size, fruit tree (57.4) for medium size whereas for large and commercial homegardens, it was higherfor coconut (51.4) and (46.9), respectively. Again they elaborated the Importance Value Index (IVI) of nine plant categories in small, medium, large and commercial homegardens and recorded higher agroecological value for V,M,O in small and large size while arecanut for medium, and commercial homegardens, similarly IVI for economic basis, V,M,O (51.5) for small size, coconut (37.9 and 36.4) for medium and large size and arecanut (37.7) for commercial homegarden.

Das and Das (2005) studied the Relative Importance Values (RIV) of homegarden plants and found the most dominant components were *A. catechu* (52.73%), *Musa* sp. (22.24%), *Artocarpus heterophyllus* (9.4%) and *Mangifera indica* (9.3%).Further, they studiedthe mean number of species per use category in homegarden and found fruit productionwas the main important contributor towards the nutrition supplement of households.

Abebe *et al*. (2019) evaluated the species richness, Shannon diversity indexand Evenness diversity index of homegardens inthe threewealth categories, and found highest Shannon diversity index in rich class and the lowest in poor class. Similar to Shannon diversity index value, highest species Evenness diversity index was recorded in rich wealth category. However, there was no significant difference among rich and medium wealth categories for richness of species.

Gbedomon *et al.* (2017) studied the proportion of threatened species hosted at PD (phyto-geographical districts) level and stated thatmore than 50% of the homegarden flora at all PDs levels were threatened, with BA (Bassila) having more than 80% of its species threatened.Moreover,the conservation status of species in HGs were categorised into: CR (critically endangered) of 41.02%, EN (Endangered) of 33.68%, VU (Vulnerable) of 18.95% and LC (Least Concern) of 6.62%. Further, considering three of the threatened species categories (CR + EN +VU), more than 90% of uncommon HG plant species were threatened.

Peroni *et al*. (2016) recorded majority of the species in the homegardens were introduced (62%) while 38% were considered native.

Krishnal and Weerahewa (2014) found maximum number of trees per homegarden was *Cocos nucifera* (3.02) and also reported the average fruit yield of different tree species which contributing towards the food security. Further, Shannon diversity index was maximum for the multi-layer homegarden system (0.86) whereas the single layer homegarden recorded (0) mean Shannon diversity index.

Amberber *et al*. (2013) stated that the value of Shannon-Wiener diversity index of studied sites ranges from 3.016 to 3.283 with highest in the Gurage C.D.S (3.283) homegarden. Again documented total of 112 plant species out of that 43 species as a food plant species, among them fruit tree (45.50%), vegetables (30.23%),pulses and cereals (13.95%), tubers and roots (10.32%) and spices (4%) thus diversity of the food crops had significant role to enhance nutritional status.

Kebebew *et al*. (2011) carried out the inventory of plants species grown in the Jimma homegarden and maximum frequency of 92.9% was recorded by avocado and all the produces from homegardens were mostly used forself-consumption by the farmers.

Kehlenbeck *et al*. (2007) studied the biodiversity of homegardens in five villages of the Napu valley, Central Sulawesiand found higher diversity parameters for homegardens of the three local villages than two migrant villages.

Sunwar (2003) studied the Shannon–Weaver, Simpson's and Evenness indices for species diversity in Terai and mid-hill ecology of western Nepal and recorded the higher Shannon–Weaver Index of homegardens in mid hill (H' = 4.42) than Terai (H' =4.25).

Kehlenbeck and Maass (2003) reported highest total number of crop species as well as average number of species per garden, species density and Shannon's Index H'were in the forest village, intermediate in the market village and lowest in the transmigrant village.

Trinh *et al*. 003) recorded highest species diversity (53.9) and range of species (20-103) in homegardens of Chau Thanh district, whereas least in the homegardens of Nghia Dan at the Central midlands region.

Conclusion

Homegardens consisting of multi-tier strata of woody perennials and crops have diverse functions of food production, conservation of biodiversity and others. Review of various aspects of biodiversity conservation and food security of homegardens exhibited that the species diversity, species richness, tree species density, Shannon's Diversity Index, Simpson's Index of homegardens indicate the conservation of biodiversity by upkeep of the native and exotic species. Similarly, homegardens are providing vegetables and fruits throughout the year which helps in reducing mal nutrition, chronic hunger and seasonal food insecurity. Thus, homegarden is an important agroforestry system in the tropics which plays a major role in the biodiversity conservation and food security.

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Seminar No. 12

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PRODUCTION TECHNOLOGY OF KHAIR (*ACACIA CATECHU* WILLD.)

Introduction

Acacia catechu (L. f.) Willd.is a member of family (Fabaceae) Mimosoideae having many important uses consisting timber, katha and cutch making with trade name of Khersal, Katha, Kath, Cutch tree, Pegu Cutch. In India, four varieties, namely: A. catechu: sub-Himalayan tract, Punjab etc, A. catechuoides:- southern peninsular India and A. sandra :-

southern peninsular India and coastal areas. A. cathechuoides:- tarai, Assam, Sikkim, Nilgiris. The generic name, 'Acacia', comes from the Greek word 'akis', meaning a point or a barb. The species name comes from 'cutch', a tanning extract isolated from its heartwood. The species is native to India, Myanmar, Nepal, Pakistan and exotic in Thailand Indonesia, Kenya, Mozambique. Acacia catechu is widely distributed throughout greater part of India except the most humid, cold and the driest regions. It is common in the sub-Himalayan tract and outer Himalayas ascending from 900 to 1,200 m from Jammu to Assam. Var. catechu – is found chiefly in Punjab, Garhwal and Kumaon region, Bihar and Orissa. Further in the sub-Himalayan tract and the outer Himalayas, it ascends upto 900-1200 m elevation.

Brief review of research works

Das (2014) observed earlier germination from the seeds originating in L2 and it was delayed in L4 seed source. The highest germination percentage (56.15 %) was found in L1 and the lowest (49.05 %) in L4. Further, seed germination started in advance for the seeds immersed in hot water (80 oC) for 10 min (S2) than other treatments, followed by cold water soaking for 24 h (S2) than other treatments. It took an average of 8 days to complete seed germination in the hot water (80 oC) and germination was completed within 5–16 days after sowing the seeds collected from all sources. The highest germination percentage (91.26 %) was noted in hot water (80 oC) for 10 min. However, in case of combined effect of seed sources and pre sowing seed treatment, highest germination percentage (95.53 ± 1.63 %) was recorded in L1S2 followed by L2S2 (93.77 ± 2.21 %) and lowest germination percentage in L4S1 (61.52 ± 1.98 %).

Khera *et al*. (2004) observed the minimum seed/ fruit length (5.9 mm), seed width/fruit diameter (4.4 mm) and seed/ fruit weight (2 g) for the small size class and increased up to large size class. Moreover, maximum germination percentage (98 % and 96 %), GV (195.9 and 47.5) and GE (93 % and 29 %) were observed in large size class followed by medium and small size class in laboratory condition and in nursery conditions, respectively. Germination rate was not different in the seed size classes and highest survival (66 %) was exhibited by large seed size class followed by medium (53 %) and small size (14 %) classes. Seeds of small size class exhibited significantly poor growth; however, medium seed size class produced superior seedlings.

Haider (2014) revealed that pre-sowing treatment of seeds in cold water for 24 hours was increased root length (4.0 cm), shoot length (6 cm), number of leaves per plant (3) and vigour index (800) at one month after sowing. Average length of shoot, average length of root and average number of leaves per plant were increased up to six months old seedlings. The seedlings planted at 2.0 m x 2.0 m spacing obtained highest germination and survival percentage of seedlings in the field for successful plantations.

Prakash and Aggarwal (2009) found maximum height (22.2 cm), root length (22.5 cm), fresh shoot weight (10.3 g), dry shoot weight (7.89 g), fresh root weight (14.3 g), dry root weight (10.09 g), VAM spore number/50g soil (12) and nodules in G. mosseae + Rhizobium sp. combination and minimum growth response in control condition. Moreover, no nodule was present either in the control or in Trichoderma viride + Rhizobium sp. treatments.

Prakash *et al*. (2009) revealed that mixed VAM showed maximum increase in height (12.3 cm), fresh weight of shoot (3.76 g), fresh weight of root (6.02 g), dry weight of shoot (3.22 g) and dry weight of root (4.48 g) followed by G. mosseae, G. fasciculatum, Rhizobium sp. and *Trichoderma viride* in non-sterilized soil.

Jhilta (2019) assessed ten diverse seed sources of A. catechu from different districts of Uttarakhand and Himachal Pradesh to represent generally novel regions. The maximum germination responses (86.66%) were recorded in Una followed by Solan and vigour testing was recorded maximum in Una (807.77) with paper towel method followed by Hamirpur (678.64). The best germination percent (82.76%) found in Udham Singh Nagar followed by Haridwar. They found significant variations among different parameters may probably be influenced by different intensities of natural constraints acting upon these traits in the prevailing geographic/climatic conditions.

Thakur *et al*. (2018) recorded highest value of sprouting (61.95 %) and average length of sprout (11.29 cm) in T1 (2000 ppm IBA) followed by sprouting (59.69 %) and average length of sprout (9.17 cm) in T2 (4000 ppm IBA) while lowest value of sprouting (37.91 %) and average length of sprout (1.47 cm) in T9 (control). Moreover, minimum time taken for sprouting (22.25 days) was recorded in T1 (2000 ppm IBA) while maximum time for sprouting was recorded in T9 (control).

Solanki *et al*. (2012) stated that the stem cutting having 20-25 cm length and 1-1.5 cm thickness of uniform hardwood cuttings treated with IBA 500 mg-1 reported maximum percentage of rooted cuttings (53.52 %), number of main roots (3.78) and length of longest root (4.27 cm) as compared to control and IBA 250 mg-1 gave best thickness of longest rooted cuttings (0.21 cm). The further stated that cuttings treated with IBA 500 mg-1 reported maximum fresh weight of root (1.52 g), dry weight of root (0.91 g) and percentage of survival cuttings (75.00 %).

Thakur *et al*. (2002) studied the in vitro regeneration of *Acacia catechu* from callus and mature nodal explants on MS medium and NAA and found that MS medium supplemented with 2,4 D (0.25 mg/l) and NAA (0.25 mg/l) enhanced callus formation; MS medium containing BAP (2.0 mg/l) and KN (2.0 mg/l) enhanced multiplication and sterilized IAA solution (10.0 mg/l) for 24 hours followed by transfer to half strength MS medium containing activated charcoal (0.02 %) resulting in rooting.

Wanage *et al*. (2013) revealed that all the trees sampled in the experiment ranged from 4.33 to 26.6 cm D.B.H. (diameter at breast height) and were grouped into VI diameter classes of 0-5 cm interval each. Similarly, the average tree height ranged from 5.34 (0-5 cm class) to 16.06 m (25-30 cm class). It was observed that the stem volume and heartwood volume increased along the diameter classes and varied significantly and reported maximum in higher diameter classes of 25-30 cm.

Anonymous (2015) concluded that Acacia catechu trees that was grown in good site had maximum tree height, diameter, and volume as compared to moderate and poor sites. The average katha yield was increased as the tree girth increased, and the crop height and crop

diameter increased as the age of the tree increased. The volume under bark and over bark increased as the DBH of tree increased. In Maharashtra and Gujarat, the extraction of katha and cutch were found maximum in factories and other small-scale units.

Jadeja *et al*. (2011) gave economics of cultivation of A. catechu in South Gujarat condition which having net realization of Rs. 74,210 with BCR (2.04).

Conclusion

The seed source paly a significant role on germination as well as growth and development of *A. catechu*. The seeds soaked in hot water (80o C) for 10 min and cold water for 24 hours enhanced germination percentage. The size of seed also plays a major role in germination. The large size seeds increased germination percentage, GV, GE and survival percentage. Moreover, seeds of small size class exhibited significantly poor growth. The seeds inoculated with G. mosseae + Rhizobium sp. and VAM enhanced growth parameters in *A. catechu*. The cuttings treated with IBA @ 500 ppm and 2000 ppm were most favourable for inducing rooting in softwood and hardwood cuttings. The MS medium supplemented with 2,4 D (0.25 mg/l) and NAA (0.25 mg/l) enhanced callus formation; MS medium containing BAP (2.0 mg/l) and KN (2.0 mg/l) enhanced multiplication and sterilized IAA solution (10.0 mg/l) for 24 hours followed by transfer to half strength MS medium containing activated charcoal (0.02 %) resulting in rooting. The growing site is also plays a crucial role in growth and development of A. catechu. The trees that was grown in good site had maximum tree height, diameter, and volume as compared to moderate and poor sites. The average katha yield was increased as the tree girth increased.

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2020-21

Seminar No. 1

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ENDEMIC SPECIES AND ENDEMISM IN INDIAN FLORA

Introduction

The term Biodiversity was first coined by Walter G. Rosen in 1986. A biodiversity hotspot is a biogeographic region that is both a significant reservoir of biodiversity and is threatened with destruction. This concept was first introduced by Norman Myers. These hotspots represent an opportunity to help conserve the diversity of life on earth. To qualify as a biodiversity hotspot on Myers 2000 edition of the hotspot-map, a region should meet two strict criteria: it must contain at least 0.5% or 1,500 species of vascular plants as endemics, and it has to have lost at least 70% of its primary vegetation. 36 hotspots have been identified all over the world; most of them are located in tropical areas. India is one of the mega biodiversity countries. India's biodiversity is estimated to be over 45,000 plant species representing about 7% of the world's flora and stands tenth in 25 most plant-rich countries of the world. Endemic elements of region throw light on the biogeography of the area, Centre of specification, area of extinction, vicariance and adaptive evolution of Flora and Fauna of the area. Many of contemporary plant geographers (Wills, 1922; Wulff, 1950; Stebbins, 1942) have also used the concept of endemic plants. Endemism in these cases refers to the "normal" or standard level of some measured observation within a specific geographic region or area. Nayar 1996 reported 3 Mega endemic centers and 40 different Hotspots in India from that 25 are micro endemic centers.

Review of literature

Jalal and Jayanthi (2012) have given state wise analysis of endemic orchids in Peninsular India which shows that Kerala (95 spp.) has a maximum number of endemic species followed by Tamil Nadu (80 spp.), Karnataka (71 spp.) and Maharashtra (36 spp.), whereas states of Andhra Pradesh (11 spp.), Odisha (12 spp.) and Gujarat (7 spp.) shows less representation of the endemic orchids.

Balachandran *et al.* (2018) studied on endemic plants of Tropical Dry Evergreen forest, Southern India and found 82 endemic species that are distributed along the Coromandel Coast of Peninsular India. These endemic species are also represented by 65 genera and 31 families, of which Leguminosae (10 spp from 7 genera) was the dominant family.

Vajravelu and Bhargavan (2000) rediscovered 11 endemic species form South India after 50 years and more and a maximum number of endemic species found belonged to family Rubiaceae (3 spp).

Vartak (2000) reported 38 endemic species from sacred groves in Maharashtra, the maximum number of Plant spp. was found in Acanthaceae and Fabaceae (4 plant spp. each) depicting the role of sacred groves in conserving endemic plant spp.

Yadav (1997) reported 49 plant species and form that 40 endemic plant spp. has been included in RDB of Indian Plants. Form these 49 plants 26 plants are endangered, 19 plants are rare and 5 plants are monotypic. He also reported that genus *Ceropegia* has highest endemic spp (33%) followed by *Dipacadi* (13 %), *Dicanthium* and *Urgenia* (10 % each).

Gopalan and Henry (2000) worked on strict endemics of Agasthiyamalai hills and reported total 125 species. Out of which 30 % are trees, 31 % herbs, 33 % shrubs and 6 % climbers. Form these total 55 % endemic plants are CE, 27 % EN, 9 % EX, 6 % V and 5 % epiphytes.

Nagar (2015) reported that Gujarat had 7 % endemics of peninsular India which includes 138 taxa belonging to 74 dicotyledons and 64 monocotyledons. Poaceae is the largest family with highest number of taxa followed by Fabaceae, Orchidaceae, Acanthaceae and Cyperaceae.

Sandhyarani *et al.* (2007) documented endemic species in Eastern Ghats and reported 80 families in which Euphorbiaceae with 66 plant spp. showed maximum endemic spp, followed by Rubiaceae (38 plant spp.), Moraceae (31 plant spp.), Lauraceae (26 plant spp.), Mimoaceae (24 plant spp.) and Rutaceae (21 plant spp.).

Sharma (2012) reported 141 endemic spp. from the states of Punjab and Chandigarh out of which 110 spp. are Dicotyledons, 19 monocotyledons, 1 Gymnosperm and 11 Pteridophytes. They also reported the threat status of endemic spp – 28 % species are Endangered, followed by 19 % data deficit, 18 % possibly extinct, 10 % critically endangered and 9 % Vulnerable.

Mir *et al.* (2019) reported 548 species distributed in 100 families and 302 genera were found Endemic in the state of Meghalaya. In terms of species richness, Orchidaceae was the dominant family with 146 spp, followed by Rubiaceae (27 spp), Acanthaceae (23 spp) and Lauraceae and Poaceae (21 spp each).

Anonymous (2017) reported State wise Distribution of Endemic plant taxa of India and found that maximum endemic species are found in state of Tamil Nadu (517 spp), followed by Arunachal Pradesh (220 spp), Maharashtra (170 spp) and Kerala (161 spp).

Nayar (1996) revealed that 25 micro endemic hot-spots of endemic plants harbors 3262 plants with 59 Endemic flagship spp, 102 Endemic keystone spp, 239 Endemic Genetic Resources spp, 186 Endemic Medicinal Plants, 2514 Critical Endangered Endemic spp. and 86 Threatened spp.

Singh *et al.* (2015) recorded total 4381 species and belonging to 1007 genera and 176 families as strict endemics to the Indian political boundary. Dicotyledons dominate the endemic flora with 3170 species (72 %) belonging with 723 (72 %) genera and 127 families (72 %),

whereas Monocotyledons are represented by 1133 species (26 %) belonging to 254 genera and 27 families.

Nayar (1996) documented Endemic Bryophytes and reported that total 58 species and 27 genera are endemic in India. He also worked on endemic Pteridophytes of India and revealed that total 230 species spread across 67 families and 192 genera are endemic to India.

Sharma and Nirmala (2015) reported 71 bamboo species with 20 genera and found that the maximum endemic bamboo genus is *Bambusa* (14), followed by *Ochlandra* (12) and *Dendrocalamus* (7).

Ragavan *et al.* (2016) studied floristic diversity of Mangroves and reported 14 Endemic species confined to India. Total 08 spp out of 14 endemics are reported from West Bengal and Orissa.

Bhuinya *et al.* (2010) reported 18 species of *Litsea* Lam. endemic to India. It is interesting to know the distribution pattern and confinement of this 18 spp of genus *Litsea* across India.

Mitra and Mukherjee (2007) revealed the unique distribution of endemic *Berberis* genera with pockets of endemism in India.

Irwin and Narasimhan (2011) studied extended distribution of endemic plants and resulted that 18 genera shows the extended distribution in <3 countries, 17 genera shows extended distribution in 03 countries, 15 genera shows extended distribution in 04 countries, 5 genera shows extended distribution in 05 countries and 6 genera shows extended distribution in >5 countries.

Conclusion

With 40 Hotspots, 03 mega endemic centres and 25 micro endemic centres across length and breadth of India, the floristic endemism harbours >4000 spp. falling in various categories of endemic spp. concept. Peninsular endemic are highest in state of Tamil Nadu, similarly sub-tropical evergreen forest region with high endemism. These 02 regions are home about to 50% of the total endemic flora. Sikkim Himalayas (including Adjacent Darjeeling Himalaya and Bhutan) micro endemic centre encompasses maximum no. of endemic spp. Highest no. of endemic spp. is confined to genus *Impatiens*, family with largest endemic spp. is Orchidaceae, along with 71 endemic bamboo spp., 13 Mangrove spp., 58 spp. of Bryophytes and 203 spp. of endemic Pteridophytes that puts India on 10^{th} position on global with respect to endemism. This is also well supported by the fact that Indian flora is represented with 59 endemic flagship spp., 102 endemic keystone spp., 239 endemic spp. as a genetic stocks, 186 endemic MAP`s, 2514 Critically endangered endemic spp. and 86 threatened endemic spp. 59.34% of total endemic spp. in Indian flora falls under CE and T categories, which further draws the attention towards immediate implementation of local and regional biodiversity conservation programme.

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Seminar No. 2

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VARIABILITY ASSESSMENT IN FOREST TREES THROUGH MORPHOLOGICAL AND MOLECULAR MARKERS

Introduction

Variation is the rule of nature and is essential for the better adaptation and long term survival of a species. Owing to wider range of distribution, variations due to genetic or/and environmental causes are certain to occur. These variations form the basis of difference between races, families and individuals. Variability assessment is the first step in evaluating the evolutionary biology and tree improvement potentials of a species. It helps to distinguish between the species/population and to screen the naturally available genetic variation for utilization in future breeding work (Thakur, 2013). The variability available in the genome of a species can be grouped in to visible or invisible and quantitative or qualitative characteristics. Morphological, biochemical and molecular characterization are some of the tools used for estimation of genetic variability. Morphological markers allow assessment of genetic variability based on individual phenotypic difference yet there are limitations associated to these markers. These limitations led to the development of molecular markers (Bekele and Bekele, 2014). Molecular marker techniques are based on naturally occurring polymorphisms in DNA sequences. These markers have several advantages and disadvantages and their choice is subjected to intended application, ease and cost involved. This seminar focuses on applicability and utilization of these techniques for variability assessment in various forest trees.

Review of literature

Morhological markers

Wisal *et al*. (2019) estimated morpho-metric variability among twenty landraces of *Robinia psuedoacacia*. Among the qualitative traits, green colour of leaf and brown colour of seed was found dominant (50%). In 45 % of samples, leaflet was alternately arranged and 55% were oppositely arranged. Seed shape showed no variation among landraces under study.

Prashetyawati and A'ida (2019) studied the leaf morphological traits of teak from three provenances. Malabar provenance had the largest differences in leaf characteristics than Muna and Java provenances. Except leaf size, Muna and Java provenances had more similar leaf

morphology in terms of leaf colour, base of blade, surface texture of leaf and veins colour than Malabar provenance. Muna provenance had bigger leaf size than Java and Malabar provenance. The edge of the leaf in each provenance was entire, similar among provenance.

A study was undertaken in a nineteen-year-old Clonal Seed Orchard of teak (*Tectona grandis* Linn. f.) by Vasudeva *et al.* (2004) to assess the extent of variation for floral traits among clones. Inter-clonal variation was significant for all the floral traits while within the clone variation was negligible. Anther filament length, style length and flower stalk length varied to a large extent (CV = 7.71, 7.37 and 7.06 % respectively) whereas, flower diameter and corolla tube diameter varied with less extent among the clones (CV = 2.89 and 2.05 %).

Damor *et al.* (2019) studied morphological variability in fruits and seeds of *Aegle marmelos* collected from 10 seed sources of Gujarat. Maximum variability was recorded in seed length (CV=10.03) and minimum in fruit diameter (CV=2.1).

Variability studies in seed sources of *Pinus wallichiana,* with respect to cone and seed traits were conducted by Rawat and Bakshi (2011). The highest coefficient of variation (58.6%) was recorded for cone weight followed by 1000 seeds weight (14.95 %) and seeds/cone (14.48%) whereas lowest was recorded for seed width (CV=7.81 %).

Gunaga *et al.* (2020) assessed the morphological variation in seedling growth attributes among seven seed sources of *Saraca asoca* Roxb. collected from Konkan region of Maharashtra. Significantly higher seedling height and root length was recorded for Dodmarg source (20.0 cm and 20.7 cm, respectively). Collar diameter and number of leaves also showed significant variation and ranged from 2.0 to 3.5 mm and 4.8 to 12.3 per plant respectively.

Kumar *et al.* (2016) studied the variations among provenance and progenies of 12 year's old *Acacia mangium* for their growth performance. Significant variation was found for all the quantitative traits studied except for number of stem (NS). On the other end, there was no significant difference recorded among most sources of variation for the qualitative traits especially for branch size (BS) and branch angle (BA).

Dutt and Tyagi (2011) investigated the morphological variation in fibers of 11 species of Eucalyptus. *E. grandis* fibers of Saharanpur origin were comparatively longer (0.92mm), wider (20.12 mm) and have wide lumen (14.32 µm) whereas, E.-348 (hybrid) recorded shorter fiber length (0.71mm), narrowest fibre width (15.2mm) and lumen diameter (5.1 µm).

Molecular markers

Butcher *et al.* (1998) estimated genetic diversity in the nuclear genome of *Acacia mangium* using 57 anonymous RFLP loci for 10 natural populations. The highest measures of genetic variation (allelic diversity, number of polymorphic loci and heterozygosity) were observed in the New Guinea populations and the lowest level of genetic variation was recorded in Sidei and Ceram.

Genetic diversity in teak in south Gujarat was assessed by Chaudhari *et al.* (2018) through RAPD technique. Highest Jacard's similarity value (0.81) was observed between Vansada and Dharampur, indicating a close relationship between these populations. The smallest

Jacard's similarity values (0.47) were observed between Vyara and Bardipada-B population indicating high variability between these populations.

Random amplified polymorphic DNA (RAPD) molecular markers were used to evaluate the genetic diversity in populations of *Melia dubia* Cav. by Johar *et al.* (2017). Cluster analysis grouped all the 24 populations into two major groups. Cluster I comprised of two out grouped accessions (MCP10 & MCP11) and cluster II consisted of the rest of 22 accessions/genotypes, indicating that *M. dubia* within India constitutes considerably narrow genetic base.

Chloroplast microsatellites (cpSSR) were used to study the genetic diversity of 10 populations of *Pinus kesiya* by Rai and Ginwal (2018). The analysis revealed a more or less equal proportion of total variation distributed within (52.81%) and among populations (47.19 %) of the total variation. However, the populations revealed relatively high genetic differentiation and inter-population diversity.

Genetic variation was assessed in eleven natural populations and seven plantations of *Melia dubia* through 15 ISSR markers by Rawat *et al.* (2018). Diversity in terms of percentage of polymorphic loci, gene diversity and Shannon information index respectively were higher in plantations (63.51, 0.24 and 0.36) as compared to natural populations (50.77, 0.21 and 0.30).

Singh *et al.* (1999) assessed genetic diversity in 37 Neem accessions from India and four exotic lines from Thailand using AFLP markers. UPGMA clustering analysis separated the 37 Indian genotypes from the four Thai lines. Neem germplasm within India constitutes a broad genetic base, on the other hand, four lines from Thailand, formed a narrow genetic base. The lowest genetic similarity coefficient value (0.47) was observed between an Indian and an exotic genotype.

Conclusion

Use of molecular markers is advantageous over conventional phenotypic characterization to detect genetic variations. Studies confirmed significant amount of inter and intra population variations in most of the morphological traits. Under phenotypic characterization, seed shape, edge of the leaf, number of stem, branch size and branch angle were some of the morphological traits, which have shown no variations among population. Whereas, characters like seed width, fruit diameter, flower diameter and corolla tube diameter have exhibited lesser amount of variation. Variability investigations through molecular markers have revealed nearly equal variability distribution within and among populations. Overall, the inter-population variability was higher in the species. Similarly, plantations recorded higher diversity as compared to natural populations. This information of variability pattern and extent will be helpful to choose traits of interest and base material for breeding programme in forest trees.

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Seminar No. 3

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SIGNIFICANCE OF SMALL CARNIVORES IN INDIAN FORESTS

Introduction

Mammals are considered to be the most successful animals on earth. Mammals encompass more than 5,500 species, spread in about 1,229 genera, 154 families and 29 orders. 422 species of mammals (7.75%) and 305 sub species of mammals belonging to 13 orders and 48 families have been reported from India (Nameer, 2015), out of which 391 species are terrestrial and 31 species are marine form. Carnivores which are less than about five kilogram in body weight are generally termed as the small carnivores. Out of the 281 species of carnivores of the world, small carnivores account for 194 species; whereas, India has 43 species of small carnivores belonging to six families: 1 of Ailuridae, 10 of Felidae, 7 of Herpestidae, 16 of Mustelidae, 1 of Prionodontidae and 8 of Viverridae(Sreehari and Nameer, 2016,Kamalakannanand Venkatraman, 2017, Wilson and Mittemmeter, 2009).

Small carnivores act as an indicator of healthy ecosystem they form an important prey base for medium sized carnivores and raptors (Mudappa*et al.,* 2010). Poaching for various parts of the small carnivores are practicing in different parts of our country. Generally, Felids, Herpestides and Mustelids are mostly poached for their skin, fur/hair and meat, whereas Viverrids are being poached for their meat, skin and scant gland to make different product from it. Generally, all species of small carnivore are facing major thrust by habitat loss, poaching, road kills, human interference, pollution, interspecific competition, fishing activities, siltation and pesticides effects harmful for their population.

Brief review of Research Work

Abroad

Johnson *et al.* (2009) studied on the diversity, status and conservation of small carnivores in a montane tropical forest in northern Laos using country's first systematic camera-trap monitoring of carnivores in the Nam Et- Phou Louey National Protected Area on the Laos–Vietnam border, with an intensive sampling across 500 km^2 from 543 to 2,288 m altitude for 8,499 camera-trap days during 2003–2006. They detected 14 species of small carnivores, including the first record of Owston's civet for Laos. Preliminary occupancy estimated for the seven most common species ranged from 11 % for Marbled cat to 42 % for Asian golden cat.

Activity patterns of viverrids were primarily nocturnal whereas mustelids, except for hog badger, were diurnal.

Shepherd (2012) worked on small carnivores in Jakarta wildlife markets, Indonesia and found six species of small carnivores during spot checks from markets in 2010 and 2012. He found Javan Ferret Badger, a little-known species rarely in trade. Most tradable species was Common Palm Civet, which is increasingly demand for the production of Kopi Luwak 'Civet Coffee'. He suggested monitoring and laws to protect the species must be enforced with scientific research.

Appel *et al.* (2013) studied on small carnivores in the Annapurna Conservation Area, Nepal using camera trapping survey. This protected area is the largest in the country and represents Himalayan mountain ecosystems. They comprised a sample effort of 370 trap days, Leopard cat was the most commonly recorded carnivore, followed by Large Indian civet and Yellow-throated marten. Also, they obtained the highest altitudinal record of a Large Indian civet in Nepal at an altitude of 2420 m. Capture rates for small carnivores were 11.56, 33.64 and 37.0 for Leopard cat, Large Indian Civet and Yellow-throated marten, respectively.

Sogbohossou and Aglissi (2017) studied using camera trapping technique at 103 sites on diversity of small carnivores in Pendjari biosphere reserve, Benin with trapping effort of 3607 days between November 2014 and April 2015. They captured 543 independents of at least ten species with 15 pictures/100 days trapping success rate. Small carnivores were found in 68.0 % of the sites. Jackal and Genet were the most abundant distributed species in the park while Mongooses and Genets were more common in hunting zones. Caracal was the less distributed in the reserve. Hunting zones being more prone to human disturbance, researcher suggested that Felidae were more vulnerable to anthropogenic activities than other carnivores. These species and Jackal could be used as indicator species in Pendjari ecosystem.

Dhendup *et al.* (2019) carried out research on distribution and status of the Manul in the Himalayas and China. using recent sightings and camera trap records from north Sikkim in India and Bhutan to the East of Himalayas. The population size and trend in the region remain unknown. The Pallas's cat was likely to be threatened by habitat degradation and fragmentation from traditional pastoralism, unregulated tourism, infrastructural developments and also by poaching, including their prey. Climate change was also an emerging threat to the species although the potential impacts remain uncertain. Moreover, the species remained one of the lesser known wild cats, research and monitoring are highly lacking. They suggested a strong need for active conservation actions and dedicated studies on Pallas's cat.

India

Mallon (1991)conducted a research on Mustelids in Ladakh and reported the outcome by his field work which was carried out on 7 visits, totaling 21 months between 1980-1989. He broadly studied larger mammals with special reference to mustelids with covering an area around 15,000 km^2 in South-Central Ladakh and found the presence of five mustelids from direct and indirect evidences *viz*., Stone Marten, Mountain Weasel, Stoat, Steppe polecat and Eurasian otter.

Choudhury (1999) worked on conservation of small carnivores (Mustelids, Viverrids, Herpestids, and Ailurid) in North Bengal. He collected data from Darjeeling, Jalpaiguri and Koch Bihar district from June to November 1995 and August to December 1996. Data including direct sightings, indirect evidences and wild-caught animalsand by collecting information from experienced hunters and forest officials and other observers and reported the presence of 1 species of ailurid, 11 species of Mustelid, 7 Viverrids, and 3 herpestids from study area.

Shekhar (2003) conducted studies on the status of Mongooses in Central India. Three species of mongoose were sighted during his study period. In central India people consider the mongoose sacred. Sighting a Mongoose is considered to bring good luck and thought to be auspicious, so most people do not kill them. Also, he found that Indian Grey Mongoose were present and found common at all study areas where as other two mongooses were not present at some study areas. He concluded that fragmentation of forests and sacred belief about mongooses had positive impact whereas caught and sold of Mongooses to check pest and road kills affects had negative impact on Mongoose's population.

Dharaiya and Gajera (2008) studied on occurrence, distribution and status of small and certain rare species of mammals in North Gujarat region. The research project was carried out for 27months; *i.e*. December 2005 to March 2008. During study region of North Gujarat is stratified into four eco-zones and each was surveyed intensively through variousmethodology such as direct encounter, sign surveys, secondaryinformation *etc*.The study found that Desert Cat and Rusty-spotted Cat facing higher threat score while Common Palm Civet had lower threat score and other small carnivores were in medium threat. Also, they found that Rusty spotted cat status was restricted while Desert cat and Common Palm civet were having a fair status in study area. Whereas, other small carnivores were found common in a study area.

Gupta (2011) conducted a research on ecology of medium and small sized carnivores in Sariska Tiger Reserve, Rajasthan, India. The study was conducted in an intensive area of 144 km^2 within the National Park area in two different seasons winter (November to February) and summer (March to June) for two successive years during 2007 to 2009. She was not found any difference in abundance estimation of small carnivores in summer season while she found difference in case of mongoose out of other studied animals in winter season between camera trap and track plot method.

Pande *et al.* (2013) carried out a study on photographic records of the Asiatic Wild cat from two states of India. The researcher had sighted two of Asiatic Wild Cat (1+3 = 4 individuals) in Shahgarh Landscape, Jaisalmer, Rajasthan. Whereas, one individual of this cat was sighted at Nauradehi Wildlife Sanctuary, Madhya Pradesh during day time only. Also, he highlighted some major threats like habitat loss and poaching, reclaiming wastelands had resulted in the destruction of the Asiatic Wild cat habitat and breeding areas in India and presently little international trade persists in Asiatic Wild cats killed for their fur in the past. Researches suggested to conserve these cats and do more study on it scientifically.

Kalle *et al.* (2014) estimated seasonal occupancy and abundance of nine small-carnivore species from camera-trap data in Mudumalai Tiger Reserve in 2010 and 2011. They deployed 25

camera-trap stations in deciduous forest, 21 in the semi-evergreen forest and 26 in the dry thorn forest. In total, 7380 trap-nights yielded 448 photographs of small carnivores: Jungle Cat (n=72), Leopard Cat (n=6), Rusty-Spotted Cat (n=11), Small Indian Civet (n=89), Common Palm Civet (n=37), Brown Palm Civet (n=20), Stripe-Necked Mongoose (n=66), Ruddy Mongoose (n = 96) and Indian Grey Mongoose (n = 51). In the dry season, Rusty-Spotted Cat was the rarest carnivore with an average abundance (λ mean) of 0.24 ± 0.26, while Ruddy Mongoose was the most abundant (λ mean = 0.90 ± 0.40). In the wet season, Leopard Cat was the rarest species (λ mean = 0.048 ± 0.041) while Grey Mongoose was the most abundant (λ mean = 0.68 ± 0.35).

Khatiwara and Srivastava (2014) studied on Red Panda *Ailurus fulgens* and other small carnivores in Kyongnosla Alpine Sanctuary, East Sikkim from November 2011 and October 2012. The first record of Red Panda in the wild; the highest elevational record of Large Indian Civet and the second-highest record of Leopard Cat globally were made; and records of Red Fox, Yellow-throated Marten and Stone Marten and Pale weasel was sighted directly.

Kumara *et al.* (2014) studied on small carnivores of BiligiriRangaswamy Temple Tiger Reserve, Karnataka and found nine species of small carnivores using camera-trapping technique, transect walks, and night surveys. They also found vegetation types strongly influences the presence and abundance of each species. The most sightings of small carnivores occurred in dry deciduous forests. Among all the species, the Asian Palm Civet was the most abundant followed by Small Indian Civet. They further found that with comparing many other forests or regions in India, the sight records of Rusty-spotted Cat were relatively higher in BRT.

Naniwadekar *et al.,* (2014) studied on records of small carnivores from in and around Namdapha Tiger Reserve, Arunachal Pradesh. Opportunistic direct observations and camera-trap records from 2008 to 2013 in eastern Arunachal Pradesh were recorded and found 11 small carnivore species of the 20 likely to occur. Observations included the first confirmed Small-toothed Palm Civet sighting from India. Also, researchers got two species of small carnivores as a dead animal *viz.,* Crab-eating Mongoose and Yellow-throated Marten.

Balaji and Satyanarayana (2016) studied on the first record of Stripe-necked Mongoose *Herpestes vitticollis* Bennett, 1835 (Mammalia: Carnivora: Herpestidae) from the Eastern Ghats of Andhra Pradesh, India. They surveyed out in Papikonda National Park and its adjacent reserve forest in 2014. Sign surveys and camera trapping was carried out to know the presence of wildlife. During this survey, three sighting records and at two different locations the Stripe necked Mongoose were camera trapped. They conformed five records of the Stripe-necked Mongoose in Papikonda National Park and adjacent reserve forests. They also found that all presence record was made inmoist deciduous forest only.

Sreehari and Nameer (2016) conducted a trail on small carnivores of the Parambikulam Tiger Reserve, Southern Western Ghats, using camera trap techniques, and reported 11 species. A total of 1,350 camera-trap nights with 242km of day transects and 344km of night transects using spotlights. This was supplemented about 90.00 % of the small carnivores captured were members of the Viverridae family such as the Small Indian Civet (31.67%), Common Palm Civet (30.00 %) and Brown Palm Civet (28.33%). The study recorded all the four species of Mongoose

known from the area. Two out of the 11 small carnivores belong to the 'Vulnerable' category on the IUCN Red List.

Sreehari *et al.,* (2016) studied on recent records and distribution of the Indian Brown Mongoose *Herpestes fuscus* from the southern Western Ghats and found that the primary habitat of Indian Brown Mongoose was the evergreen forests, high altitude grasslands-shola forests and adjoining tea and coffee plantations. Five independent sightings of the Brown Mongoose were made from the evergreen forest near two camp sites in Peppara Wildlife Sanctuary, Thiruvananthapuram, Kerala. One pair was observed frequenting the premises of the camp shed during the day and night for feeding from the liter. A total 12 sightings were done directly of the Indian Brown Mongoose in which mostly sighted by direct observations and only one-time camera trapped.

Nikhil and Nameer (2017) conducted a research trail on small carnivores of the montane forests of Eravikulam National Park in the Western Ghats using the camera trapping technique and recorded nine species of small carnivores. These include 3 species of Herpestidae, 2 species each of lesser cats Felidae and Viverridae, 1 species each of Mustelidae. It was interesting to note that the Felines (lesser cats) were the more common small carnivores in the montane forests. Jungle Catwas the most abundant small carnivore, which was followed by Leopard Catand Stripe-necked Mongoose.

Sanghamithra and Nameer (2018) conducted a study on small carnivores of Silent Valley National Park, Keralafrom September 2015 to April 2016, using the camera trap technique. Seven species of small carnivores were recorded during the study. The most common species of small carnivore of SVNP was Small Indian Civet (44.0 %) followed by Brown Palm Civet (20.0 %) and Stripe-necked Mongoose (17.0 %). The other small carnivores found at SVNP were Brown Mongoose (7.0 %), Leopard Cat (6.0 %), Asian Small-clawed Otter(5.0 %) and Nilgiri Marten (1.0 %).

Sreekumar and Nameer (2018) studied on small carnivores of Wayanad Wildlife Sanctuary, Southern Western Ghats using camera trapping technique at 111 camera trap locations between November 2016 and February 2017. They reported presence of nine species of small carnivores belonging to four families (1 of Mustelidae, 3 of Viverridae, 3 of Herpestidae and 2 of Felidae). The most common and abundant species was Small Indian Civet, followed by Stripe-necked Mongoose and Common Palm Civet. Among these Asian small-clawed Otterand Leopard Cat were rare species. The time activity pattern of small carnivores revealed that, all the viverrids were having exclusively nocturnal activity pattern while the Ruddy Mongooseand Stripe-necked Mongoose were showing diurnal activity pattern.

Conclusion

Small carnivores are important part of our ecosystem and act as an integral component of forest animal communities, contributing to energy flow and nutrient cycling and playing enormously important roles as predators and seed dispersal, indicator of an ecosystem and pollination agents in Indian forests. Effective conservation of small carnivores requires detailed knowledge of their current distribution, population status and ecological requirements.

Generally, species distribution can well understand by frequency of detection like Viverridae are more likely to detect followed by Herpestides. All species have different capture rate according to methodology, study place, study time and species abundance. Also, knowledge on activity pattern may vary from animal to animal like viverrids were having exclusively nocturnal activity pattern while Mongooses were showing diurnal activity pattern.Although our understanding on their distribution and ecology had increased, comprehensive information at a regional scale in most parts of the country is still lacking specially in case of Gujarat and India. More research on small carnivores should be encouraged and conservation initiatives in scientific manner can overcome the threats to wildlife. Protecting small carnivores require joint effort of everyone including local communities. In fact, local communities are the most effective conservationists. Without their support, no conservation is longlisting. Some of the activities that communities can do to protect them by stopping illegal hunting and poaching, by protect the forest, by reduce unnecessary use of pesticides and insecticides, by spreading message of importance of these animals and by sharing knowledge to conserve these species in nature. Also, well developed policies and laws can greatly helpful to conserve and protect these animals.

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Seminar No. 4

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SALINITY TOLERANCE MECHANISM IN TREES

Introduction

Soil salinization is a global problem that seriously affects plant growth and development. Soil salinization affects 8.31 billion $hm^2$of land, making it an ecological problem worldwide. Planting salt-tolerant species in saline–alkali areas can maintain productivity. High-salt content in soil directly damages plant cells, tissues,and organs,which affects tree growth throughout the life cycle.Screening and introducing highly salt-tolerant trees and implementing specialized

cultivation techniques are effective measures to increase the germplasm resources of salt tolerant trees and improve saline soil management.

Review of litersture

Deinlein *et al*. (2014) inferred that high-salt conditions in the soil reduce the water potential of the plant root surface, reducing the plant's ability to absorb water and causing osmotic stress.

Yuan *et al*. (2016) inferred that salt absorbed by the roots is transported to shoots and accumulates in leaves, causing ion homeostatic imbalance in the cell and, ultimately, ion poisoning.

Munns and Tester (2008) found out that the cytosolic K^+/Na^+ ratio is a key determinant of plant salt tolerarance.

Liu *et al.* (2014) reported that in *Elaeagnusangustifolia* seedlings, more Na^+ in roots but reduced Na^+ accumulation in the crown tissues.

Chen *et al.* (2003) reported that *Populuseuphratica*restrict uptake and transport of Na^+ in roots.

Qi *et al.* (2018) found out that Na^+ is the main inorganic osmotic adjustment element in *Nitrariasibrica*and *Tamarixchinensis*.

Hmida-Sayari *et al.* (2005) heterologously expressed P5C5 from *Arabidopsis thaliana* in *Solanum tuberosum*withincreased proline levels.

Zhu (2003) found out that Vacuolar Na^+/H^+ antiporter genes AtNHX1 and plasma membrane Na^+/H^+ antiporter gene SOS1 are closely related to intracellular ion balance in *Arabidopsis thaliana.*

Li *et al.* (2009) also heterologously expressed *Solanum lycopersicum*jasmonic ERF in *Populusalba*x *Populusberolinensis*which enhancedgrowth and showed no symptoms of salt damage.

Gao *et al.* (2013) successfully expressed LEA gene from *Tamarixchinensis*x *Tamarixandrossowii*in *Populussimonii*x *Populusnigra which* improved salt tolerance by protecting cell membranes.

Thomson (1988) found trade-off between salt tolerance and yield at lower salinities in *Eucalyptus camaldulensis*through conventional breeding.

Gao *et al.* (2000) reported that Cod A, a gene from *Arthrobactesglobiformis*in *Diospyros kaki* enhanced salt tolerance.

Conclusion

Forests play an important role in improving the ecological environment and global greening, but compared with crop research, studies of salt tolerance of forest trees, the selection of germplasm resources, and research on resistance breeding are lagging. Salinized land is expanding, and few tree species possess sufficient salt tolerance to grow in such areas, making salt tolerance research in trees critical. Natural halophytes such as *Tamarixchinensis*and *P. euphratica*are treasure troves for studying salt tolerance molecular mechanisms and cloning salt-tolerant genes. The mechanism for obtaining new salt-tolerant genotypes of trees is more

complex, involving many genes regulated by multiple pathways. In future research, the molecular biology of trees under salt stress conditions should be examined, with a focus on stress signal transduction and salt-resistance genes and proteins.

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Seminar No. 5

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Degree: M.Sc. Forestry (Forest Products Utilization)	**Course No:** FOR 591
Major Advisor: Dr. S. K. Sinha	**Venue**: Room No. 101
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EFFECT OF PHYSICAL PROPERTIES AND CHEMICAL COMPOSITION ON CALORIFIC VALUE OF HARDWOOD

Introduction

Wood is a porous and fibrous structural tissue found in the stems and roots of trees and other woody plants. Anatomically, it is secondary xylem in the stems, roots and branches of trees and shrubs (Sinha and Desai, 2019). Wood has been used for thousands of years for fuel, construction material, furniture, paper& pulp, tools, weapons, and in several applications. It consists of bark as an outermost layerenclosing sapwood and hardwood inside it. Sapwood is moist, light, living in nature, while heartwoodis darker, harder and dead.

There are two kinds of wood in nature softwood and hardwood. Hardwood is also known as an angiosperm and softwood is known as a gymnosperm. Microscopically, softwood is nonporous and hastracheids, whereashardwoods is porous and havevesselsand fibers.Wood is chemically composed cellulose, hemicellulose, lignin, extractives and ash content. Density and moisture content are important physical parameters that determine the most of wood properties.

The calorific value of wood is defined as "the total amount of heat liberated, when a unit mass of wood is burnt completely" (Anon., 1970).The calorific value of wood is generally influenced by physical properties (moisture content and density) and chemical compositions (cellulose, hemicellulose, lignin, extractives and ash content). Hence the present research work reviews the available literature to know the details of relationships among physical properties, chemical compositions and calorific value of different hardwoodspecies.

Review of literature

Effect of physical properties on calorific value

Sinha *et al.* (2018) studied the relationships among basic density and moisture content of 21 hardwood species at College of Forestry, NAU, Navsari and reported that calorific value of branch wood significantly increased with increase in basic density and its value decreased with increase in moisture content.

Yuliansyah and Amirta (2016) investigated the physico-chemical properties and energy potency of wood waste biomass four *Shorea* sp.They revealed high wood density (857 kg/m^3)and high calorificvalue (17.90 MJ/kg)in *Shorea laevis*; howevercalorific value (16.86 MJ/kg) of *S. gibbosa* decreased with decrease in wood density(494 kg/m^3).

Akhator *et al.* (2017) studied the physico-chemical properties and energy potential of five hardwood sp. from wood waste inNigeria andobserved low calorific value (19.56 MJ/kg) in *Nesogordonia papaverifera* havinghigh moisture content (13.34%) and high calorific (20.15 MJ/kg) in *Terminalia ivorensis* having low moisture content (9.52%).

Puri *et al.* (1994) examined the fuelwood value index of ten hardwood tree species of aridregion in Raipur, Chhattisgarh and found that *Casuarina equisetifolia* possessed high fuel value index (2815) with high density (0.87 g/cm^3) and low moisture content (51.9%).While, *eucalyptus camaldulensis* showed low fuel value index (562.9) with low density (0.65g/cm^3) and high moisture content (60.9%).

Evbuomwan and Okorji (2018) analysed the fuel wood propertiesof selected six Nigerian hardwood trees and reported that *Gmelina arborea* produced the best fuel value index (190.64) irrespective of its low density (0.44 g/cm^3) because of low ash and moisture content.

Asibor *et al*. (2019) studied the effect of density on calorific value of 110 years old ten tropical tree species in Nigeria and revealed that *Afzelia africana* has high calorific value (19.066 MJ/kg) with high wood density (790 kg/m^3).

Kumar *et al*. (2009) examined the effect of wood density on calorific value of seven fuelwood speciesin Gujarat and found that *Sterculia urens* has low calorific value (19.70 MJ/kg) with low wood density (686kg/m^3). However, *Acacia nilotica* have high calorific value (23.40MJ/kg) with high wood density (978kg/m^3).

Chakradhari and Patel (2016) investigated on the combustion characteristics of 15 tropical treesin Raipur, Chhattisgarh and reported that the calorific value (CV) of *Terminalia bellirica* was high (8130 kcal/kg) with low moisture content (2.7%). While, the CV of *Annona squamosa* was reported to be low (5190 kcal/kg) with high moisture content (5.9%).

Ojelel *et al*. (2015) studied the effect of physical properties on fuel value of ten tropical fuelwood species in Uganda. Theyreported high (13.09) fuel value index (FVI)with high wood density (0.65 g/cm^3) and low moisture content (36.18%) in to 13.09 in *Albizia grandibracteata* while, low FVI (1.10) is reported with low density (0.23 g/cm^3) and high moisture content (69.41%) in *Ficus natalensis*.

Strohbach *et al.* (2015) compared the effect of wood density on calorific value of the *Prosopis* sp. and *Acacia* spp.by studying the several literatures at Namibia and concluded that the calorific value of wood increased with increase in wood density. Furthermore, *Acacia* sp. has high calorific value than *Prosopis* sp.

Effect of chemical composition on calorific value

Prasad (2017) studied the effect of ash content on calorific value of ten firewood species in Mysore, Karnatakaand found high calorific value in *Meliosimapinnata* (6713 cal/g) and *Gmelina arborea* (6134 cal/g) with low ash content (2.30% and 2.33%) respectively. However, *Acacia catechu* haslow calorific value (4986 cal/g) with high ash content (5.80%).

Mitchual *et al*. (2014) examined thefuelwood properties of six tropicalhardwood timber species in Ghanaand reportedhigh gross calorific value (GCV) in *Terminalia superba* and *Piptadenia Africana* with low ash content while, recorded low GCV in *Aningeriarobusta* and *Ceiba pentandra* with high ash content.

Chavan *et al*. (2015a) studied effect of chemical composition on the calorific value of *Prosopis juliflora* and *Leucaena leucocephala* at TNAU, Mettupalayam.The recorded high calorific value (CV) in *Prosopis juliflora* with high lignin content and recorded low CV in *Leucaena leucocephala* with low lignin content.

Chavan *et al.* (2015b) investigated the effect of chemical composition on the fuelwood characteristics of ten tree species from Bundelkhand, U.P. They reported high calorific value (4946.06kcal/kg) in *Acacia catechu* with high lignin content (34.13%). However, they recorded

lowest calorific value (4433.89 kcal/kg) with lowest lignin content (19.58 %) in *Leucaena leucocephala*.

Khider and Elsaki, (2012)studied the effect of chemical composition on the heat value of four hardwood species from Sudanandrecordedhigh gross calorific value (GCV) in *Acacia mellifera* withhigh holocellulose content and low GCV in *Moringa oleifera*with low holocellulose content.

Sedai *et al*. (2016)investigated the effect of chemical composition on the heating value of 18 tropical fuelwood species from Assam and reported high heating value (HHV) in *Dysoxylum procerum* (20.09 MJ/kg) with high cellulose (46.82%) and lignin content (21.96%)and low ash content (0.7%). However, the HHV in *Bauhinia variegata* was low (16.83MJ/kg) with low cellulose (32.54) and lignin content (17.09%) and high ash content (6.13%).

White (1986) studied the effect of lignin content and extractives on the calorific value of four temperate hardwood species at Madison, USA. They reported high calorific value in hardwoods having high extractive and lignin content.

Kumar *et al*. (2020) examined the effect of extractives on the calorific value and ash content of wood in *Prosopis juliflora* and *Lantana camara* at IWST, Bengaluru. They recorded high calorific value and high ash content in unextracted wood in comparison to extractive free wood.

Nasser and Aref (2014) studied the effect of chemical composition on the calorific value of 20-25 years old six *Acacia* sp. in Saudi Arabia and revealedthat *Acacia* sp. with high extractive and lignin content and low ash content have high calorific value and vice-versa.

Conclusion

It is concluded that calorific value or fuel value of wood generally increases with increase in wood density, Klason lignin, extractive, cellulose and hemicellulose, while this value decreases with increase in moisture content and ash content of wood. Furthermore, wood containing high lignin and extractives have higher calorific or fuel value than wood containing high cellulose and hemicellulose.Among several hardwood species, *Acacia* sp. (*Acacia catechu, A.nilotica, A. senegal, A. leucophloea, Acacia auriculiformis, A. tortilis, A. asak, A. etbaica, A. gerrardii, Acacia mellifera), Casuarina equisetifolia, Prosopis juliflora, Dysoxylumprocerum, Terminalia ivorensis, Terminalia superba,Terminalia bellirica, Dalbergia sissoo, Meliosmapinnata, Gmelina arborea, Albizia grandibracteata, Afzeliaafricana,Tamarindus indica* are reported to be high in calorific or fuel value.

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Seminar No. 6

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RICE BASED AGROFORESTRY SYSTEMS

Introduction

The *Oryza* genus is thought to have originated about 14 million years ago in what is now South-east Asia and the Philippines, Rice is one of the most important cereal crop next to maize and wheat. It is a monocot plant which includes 23 wild and 2 cultivated species *viz. Oryza sativa* and *Oryza glaberrima.* In India, rice (*Oryza sativa*) is the most important food crop, it is not only an integral part of daily diet but also an integral part of spiritual religious ceremonies and holy festivals. India ranks first in area and second in production of rice, after China. Within the country, rice occupies one-quarter of the total cropped area that contributes about 40 to 43 % of total food grain production and continues to play a vital role in the national food and livelihood security system. In India, rice is grown under widely varying condition of altitude and climate. Rice cultivation in India extends from 8^0 to 35^0 N latitude and from sea level to as high as 3000 meters. Rice crop needs a hot and humid climate. It is best suited to region having high humidity, prolonged sunshine and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21^0 C to 37^0 C. However, it can tolerate maximum temperature up to 40^0C to 42^0C.Asia accounts for over 90 % of the world's production of rice, with China, India and Indonesia producing the most. Only 6-7 % of the world's rice crop is traded in the world market. 85% of the rice that is produced in the world is used for direct human consumption. Rice can also be found in cereals, snack foods, brewed beverages, flour, oil, syrup and religious ceremonies to name a few other uses. The flooded rice paddy is a field of aquatic biodiversity, providing a home for fish, plants, amphibians, reptiles, mollusks, and crustaceans, which many of can be used as a means to incorporate protein into the diets of poor and malnourished people in low and middle income countries that farm rice.

Brief review of research work

Bargali *et al.* (2008) observed that the tree age and distance from the tree base significantly affect all the crop parameters with or without branch cutting, whereas the interactions of age and distance significantly affect the grain yield and plant density. They further reported that removal of 10 % of tree branches increased grain yield from 4.7 % under 9 years old tree to 28.8 % under 28 years old tree as compared to open area.

Islam *et al*. (2006) revealed that without any competition (absent of tree) control produced the highest number of tillers per hill (9.25), plant height (114.00 cm), panicle height (26.13 cm), grain/ panicle (103.60), chapy grain/ panicle (11.30), thousand grain weight (25.30 g) and yield (5.46 t/ha) with minimum non-effective tillers/ hill (1.25) and in case of various pruned trees highest average number of tillers per hill (7.44), plant height (103.62 cm), panicle height (22.35 cm), grain/ panicle (80.50), chapy grain/ panicle (20.50), thousand grain weight (24.63 g) and yield (3.63 t/ha) was produced under severely pruned tree while lowest was observed under light pruned tree. They further observed that among the four orientations highest plant height (103.51 cm), grain/ panicle (80.47), thousand grain weight (24.47 g) and yield (3.86 t/ha) with lowest number of chapy grain per panicle (20.82) was found in south orientation as compared to other plantation orientations. Moreover, in case of interaction of tree canopy and orientations, all the parameters were recorded maximum in open condition. Among different treatment combinations majority of parameters were responded well in treatment combination of T_1O_W and T_1O_S.

Sharma *et al.* (2011) revealed that tree height (10.81 m), bole height (3.51 m), diameter at breast height (26.02 cm), number of leaves per branch (44.85), crown length (4.29 m), crown width (3.26 m)and number of branches (10.32) of teak was significant increased by rice basedagroforestry system as compared to sole plantation.

Singh *et al.* (2016) revealed that as the distance from the tree base increased the yield of different varieties of rice increased. However, maximum grain yield was found in 2.5 m distance from the tree base (1.87 t/ha). Among different varieties, NDR-359 performed better as compared to others.

Channabasappa *et al.* (2007) observed that 12 year old *Acacia auriculiformis* raised as a bund crop reduced the yield parameters. Maximum reduction was noted near the bund. As the distance from the bund increased it increased the yield parameters due to increase in light transmission ratio. The number of panicles per m^2 (290.37), panicle length (20.93 cm) and number of panicles per hill (5.97) of rice was noted maximum in open condition which was followed by 10m from tree row.They further stated grain yield (4251 kg/ha), straw yield (6430 kg/ha) and number of tillers (6.25) was also noted in control which was followed by 10m distance (4070 kg/ha, 6587 kg/ha and 5.67, respectively). The lowest yield parameters were recorded at 2m distance. This might be due to competitive effect of tree species for available growth resources.

Kumar *et al.* (2011) conducted an experiment to evaluate growth of Salix with rice crop. They recorded the highest tree height (4.80 m) and diameter (6.9 cm) at breast height in salix clone UHFS-1 grown under agroforestry system of rice cropping system. The slight reduction in

yield was registered under agroforestry system as compared to open condition. The maximum yield of rice was noted in control (50.50 q/ha) which was on same bar with salix clones UHFS-3 (49.50 q/ha), UHFS – 5 (48.80 q/ha), UHFS- 4 (48.40 q/ha), UHFS-2, 8 and 11 (48.20 q/ha).

Verma and Rana (2014) reported less paddy grain yield under tree canopy (1.99 t/ha) than open area (2.34 t/ha).While, the straw yield was noted more under tree canopy (2.10 t/ha) than open area (1.85 t/ha). Moreover in case of various sites, the grain yield and straw yield was noted maximum in site – II (2.51 and 2.11 t/ha, respectively) in open area and in site – I under tree canopy area (2.11 and 2.50 t/ha, respectively).

Rao *et al.* (2016) studied the growth and yield performance of paddy (Sarjoo-52, Narendra Usar- 2 and 3) under four-year-old *Dalbergia sissoo* based agri-silviculture system. Results indicated that variety and distance was certainly affected the yield of paddy crop. Among all three varieties of paddy crop, the maximum grain yield (2.33 t/ha) was registered in Narendra Usar – 2 variety in open area whereas, the maximum straw yield (2.49 t/ha) was also observed in Narendra Usar – 2 variety when grown at 1.0 m away from the tree base.

Panwar and Chakravarty (2011) found that *Salix tetrasperma* was the best tree out of the three tree species taken as its canopy allowed more PAR above paddy (1305.11 $\mu mols^{-1}m^{-2}$) to penetrate and had less LAI (2.78). As a result, the yield of paddy was more (3.79 t/ha). The best combination of species and distance from tree was *Salix tetrosperma* (6×6 m) at 3 m distance from the tree as the highest yield was 4.01 t/ha, PAR above paddy (1383.66 $\mu mols^{-1}m^{-2}$) and lowest LAI (2.18).

Nayak *et al.* (2014) reported that the 75% pruning with MR-219 gave more benefit: cost ratio (3.69). No pruning recorded the lowest B:C ratio. The pure plantation without rice exhibited maximum B:C ratio (6.53) under no pruning and it decreased with increase of pruning intensity. They further recorded the higher average net monetary return in *D. sissoo* 50% pruning + rice crop (Rs. 40,311) which was followed by 75% pruning (Rs. 40,186), 25% pruning (Rs. 36,517) and lowest in no pruning + rice (Rs. 25,859). MR-219 recorded significantly higher average monetary return (Rs. 38715) closely followed by IR-36 (Rs. 30,675).

Viswanath *et al*. (2000) stated that by the agroforestry (rice + babul) system, farmers get higher cash returns on a short term (10 year) harvest cycle of trees, and labour input on farms was distributed more uniformly throughout the year than in rice monoculture.

Mondal *et al.* (2013) noted that grain yield of rice was not significantly affected by alley width but maximum grain yield (2.61 t/ha) was noted in 4.5 m alley width while effective grain yield (2.94 t/ha) in 3 m width. However, N_0 +PM treatment yielded 37% more yield over control.

Singh *et al.* (2008) revealed that *Butea monosperma* tree reduced the shoot number, shoot biomass and grain yield of paddy. The shoot number (205.0 ± 5.2 m^2), shoot biomass (9.8 ± 0.25 Mg/ha) and grain yield (3.3 ± 0.07 Mg/ha) were minimum near the tree base and they were gradually increased as the distance from tree base increased. The shoot number (305.6 ± 9.8 m^2), shoot biomass (12.6 ± 0.40 Mg/ha) and grain yield (5.2 ± 0.20 Mg/ha) were recorded maximum at D_5 (17.0-20.0 m).

Kajal *et al.* (2012) concluded that variety Binadhan-7 (V_1) appeared to be best than other variety with the higher values of number of grains per panicle (152.7), 1000 grain weight (20.33 g), yield per plot (2.53 kg) and yield (3.63 t/ha) with minimum unfilled grain per panicle (5.03) under rice + mango based agroforestry cultivation system.

Conclusion

From the above findings it is concluded that the growth and yield of rice under rice based agroforestry system was gradually reduced as compared to grown under different trees. Maximum reduction growth and yield of rice was noticed near to tree base and as the distance from the tree base or bund increased it increased the growth and yield parameters of rice. Pruning of trees considerably increased the growth and yield parameters of rice and reduced the cost of fertilizers. The rice can be successfully grown under *Tectona grandis*, *Acacia auriculiformis*, Salix clones, *Dalbergia sissoo*, *Populus deltoides*, *Salix tetrasperma*, *Acacia nilotica*, *Butea monosperma* and *Mangifera indica*.

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Seminar No. 7

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ALTITUDE VARIATION IN AGROFORESTRY SYSTEM PRODUCTIVITY IN INDIA

Introduction

India is the cradle of agroforestry with diverse kinds of agroforestry (AF) systems practised since time immemorial (Kumar *et al.,* 2012). These include the tropical, subtropical, and temperate AF systems (AFS). The elevation of landscape is a base for understanding the relationship between climate and vegetation. The primary function of most agroforestry practices is more production either directly (producing wood yield, fuel wood, edible fruits, nuts grain, rhizomes and tubers, leaves, flowers, etc.) or indirectly (facilitating enhanced and/or sustained production). Numerous agroforestry systems both natural as well as planted have been developed in different agro-climatic regions of the country, which have been found highly productive.The presence of woody perennials on the field contributes higher in biomass production and made system sustainable.By developing positive ecological and economical interactions between components, agroforestry systems aim to increase production (Sanchez, 1995).

Review of literature

Bijalwan *et al.* (2009) recorded that *G. optiva*has highest standing volume in northern aspect (5.54) and southern aspect (4.52 m^3ha^{-1}), followed by *Pinus roxburghii* (3.64 m^3ha^{-1}) in northern aspects (sites-N) and *Melia azedarach* (2.88 m^3ha^{-1}) in southern aspects (sites-S). The distribution of biomass under traditional agrisilviculture system shows that *G. optiva*has highest biomass followed by *Celtis australis* in both the aspects. In northern aspects, the productivity under traditional agrisilviculture system (crop + tree) was 24% higher than that of sole/pure agricultural crop, whereas in southern aspectit is 21% higher than that of pure agricultural crop. Overall the average productivity in northern aspect was recordedto be 16.50% higher than that in southern aspect.

Datta and Singh (2007) reported that in Agri-silvi system productivity of direct seeded upland rice, groundnut and sesamum underwent a variation from 1.25 to 1.45 Mgh m^{-2}, 0.31 to 1.14 Mgh m^{-2} and 0.38 to 0.74 Mgh m^{-2} respectively. In Horti–silvi system the productivity of pineapple and turmeric varied from 2.34 to 9.29 Mgh $m^{-2}$and 1.87 to 4.17 Mgh m^{-2}. In silvi-pastoral system cowpea productivity from 1.87 to 9.94 Mgh m^{-2} was recorded. Timber volume was variedfrom 635 to78.5 m^3hm^{-2}.Fuelwood productivity recorded lowest and highest in *D. sissoo*and *G. arborea*respectively.

Swamy and Puri (2005) observed that in winter season maximum crop productivity under *Gmelinaarborea*was found in wheat in all 3 years. While in rainy season it was recorded maximum in soyabean in all 3 years.

Gill *et al.* (2009) revealed that the grain yield decreased significantly as the sowing of wheat was delayed. They found that the grain yield of varieties PBW 502 and PDW 274 was higher than other varieties at different sowing dates. The average grain yield was the highest in PBW 502 (2.57 Mg ha^{-1}), which was significantly higher than all the other varieties.

Yadav (2010) estimated biomass of different agroforestry system. They recorded that greater above ground biomass and below ground biomass was found in *Populus deltoids* + wheat followed by *Populus deltoids*+ lemon grass.

Kumar *et al*. (2018) recorded the maximum (5.35 t ha^{-1}) cured yield under agroforestry as compared to open system 5.04 t ha-1). Similarly maximum fresh rhizome yield was also reported in agroforestry system.

Singh *et al.* (2014) observed that the total biomass (straw + grain) as well as grain yield of wheat did not differ among different combinations during 2007 to 2010.The highest wheat yield (4.57 Mg ha^{-1} total and 1.61 Mg ha^{-1} grain) was in the sole wheat plot. Among the horti–silvi combinations, ZM + PC showed the highest total yield (3.91 Mg ha^{-1}).

Dev *et al.* (2020) reported that the system productivity expressed in terms of chickpeaequivalent yield varied in the range of836 to 1015 kg ha^{-1} (sole bamboo), 3088 to3129 kg ha^{-1} (bamboo-based AFS) and2405 kg ha^{-1} (sole crops) during 7th year of study.However, during first 4 years, system productivity wasobserved relatively much higher in agroforestry system(T1 and T2) and sole crop (T5) as compared to solebamboo (T3 and T4).

Goswami *et al*. (2014) estimated biomass of different land use system. They observedmaximum biomass with different agroforestry system.

Murthy *et al*. (2013) studied the total biomass of different agroforestry system of 4 each villages of Karnataka and Tamilnadu. They observed maximum biomass in 2 of 4 villages of Tamilnadu than Karnataka and it is range from 1.33 to 13 t/ha.

Rai *et al.* (2009) conducted studies with eight tree species in grassland for 15 years (July, 1988 to June, 2003) under semiarid condition to select suitable tree species in grassland and sown pasture for higher production. They recorded that total productivity of *A. procera* was the highest (8.60 t/ha/yr), followed by *E. tereticornis* (6.92 t/ha/yr), *A. lebbeck* (6.52 t/ha/yr), *E. officinalis* (6.25 t/ha/yr) and *D. sissoo* (5.41t/ha/yr).

Patel *et al*. (2017) recorded maximum yield of paddy in control condition. However biomass production of *D. sissoo* was varied with different pruning intensities.

Rana *et al*. (2020) observed the biomass of *Grewiaoptiva* under agroforestry system in different altitude. They recorded the highest total biomass (59 t ha^{-1}) in Naithana village of Lower altitude followed by Sendri village (57.2 t ha^{-1}) of middle altitude, Ulana village (54.9 t ha^{-1}) of upper altitude.

Panchal *et al.* (2017) studied different prevalent agroforestry systems of Navsari, Gujarat. They reported maximum fruit yirld (9360 kg/ha) was obtained from both ASH system (Teak + Mango + Brijal) and (Mango + Cabbage) respectively.However maximum intercrop yield was obtained from Agri- silviculture system (Teak + Sugarcane).

Prasad *et al*. (2016) recorded greatest marketable and total biomass in 6x1 m spacing of eucalyptus. However, among different spacing greater cowpea and fodder yield was found in 10x1.5 m and 11x1 m spacing respectively.

Chand *et al.* (2005) observed that eucalyptus wood yield (206.8 t/ha.) was highest with potato, inter crop during 1987 as well as in second and third rotation (269.5 and 404.3 t/ha.)in same treatment. Similarly branch and leavesand intercrop yield was higher with treatment T_4(Potato with eucalyptus). In acacia based system wood yield was more with geranium (145.2 t/ha). While intercrop yield was found maximum in acacia with potato.Further, higher yields of intercrops were recorded for almost all the treatments in acacia based system.

Ramgopal *et al.* (2016) revealed that higher above ground biomass (20.29 t/ha), volume (34.53 m3/ha) and intercrop yield (26.04 t/ha) was found in khatiyargam (Altitude – 1495-1527 m) village.

Singh and Oraon (2017) reported that the wood volume was found highest,under agrisilviculture in *Leucaena leucocephala* (112.00 cu.m.ha^{-1}), under agrihorticulture in *Sygygiumcumini* (52.00 cu.m.ha^{-1}), in silvipastoral *Dalbergia sissoo* (37.50 cu.m.ha^{-1}), whereas in homegarden *Gmelina arborea* producedmaximum wood volume (100.00 cu.m.ha^{-1}). However intercrop yield was found varied with different agroforestry system.

Dalal *et al.* (2019) concluded that among different agri-horti-silviculture combinations, Guava + Khejri exhibited highest yield.

Sharma *et al.* (2017) recorded maximum fruit yield of mango and volume of gamhar in Gamhar+Mango+ Groundnut based agroforestry system.

Singh *et al.*(2019) reported highest total biomass (t/ha) in agrihortisilviculture (86.48 t ha^{-1}) followed by horticulture (74.25 t ha^{-1}), agrihorticulture (71.56 t ha^{-1}), agrisilviculture (57.48 t ha^{-1}), silvopastoral (43.51 t ha^{-1}), agriculture (21.98 t ha^{-1}) and grassland (3.52 t ha^{-1}) use systems.

Chisanga *et al*. (2018) concluded that the total biomass (above + below) is significantly influenced by Land use system (LUS) and altitudinal gradient. Maximummean total biomass (104.10 t ha^{-1}) was found inthe T_5 (silvipasture) LUS. However, among altitude ranges highest mean total biomass was observed in the altitudinal ranges2440–2710 m.a.s.l.

Rajput *et al. (*2015) estimated total biomass of different land use system. They found that total biomass was maximum in orchard - cereal–cereal land use system (99.23 Mg ha^{-1}). While minimumtotal biomass was recorded in vegetable–vegetable (10.28 Mg ha^{-1}) cropping system.
Bijalwan and Dobriyal (2014) revealed that higher elevation (1500-2000 m) was observed in a reduction of yield attributes of wheat compared to middle elevation (1000-1500 m). Further, they reported that there was a reduction in grain, straw and biological yield of wheat on the southern aspect compared to northern aspect on both elevation level under traditional agroforestry systems.

Conclusion

The geographic and climatic conditions change sharply along the altitude. This change leads to change in composition of tree-crop combinations in different agroforestry

system.Various Agroforestry systems like Agri-silviculture, Agri- horticulture, Silvopasture, Horti-pasture, Agri-horti-silviculture are commonly practiced along altitudinal gradient..Productivity of agroforestry systems depends on a number of factors including the growth habit of the species, site quality, age, management practices, interaction between trees & understory crops. Productivity of Agroforestry system decrease towards higher altitude.

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Seminar No. 8

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TELEMETRY: IT'S APPLICATIONS IN WILDLIFE STUDIES IN INDIA

Introduction

Radio-telemetry technology and tracking methods for studying the behavior and ecology of wild animals have advanced significantly ever since radio telemetry was first used in the 1960s (Cochran and Lord, 1963). It is defined as sensing and measuring of information at some

inaccessible locations and then transmitting that to a central system to monitor and further analyze it. It was L.D. Mech, from the US Fish and Wildlife Service, who brought the technology to India in 1976 for preliminary trials. Under the Project Tiger, two sambars (*Rusa unicolor*), three nilgai (*Boselaphus tragocamelus*), two chitals (*Axis axis*) and one wild boar (*Sus scrofa*) were collared and tracked from 1976 to 1980. In 1980, one Asiatic elephant (*Elephas maximus*), one tiger (*Panthera tigris*) and one Asiatic lion (*Panthera leo persica*) were also radio-collared and tracked. After the initial training, the telemetry equipment was left with Project Tiger personnel to track these animals and practice the technique.

From 1983 to 2013, 82 studies have been conducted on 47 animal species from four taxonomic classes using the telemetry technique. In India, most of the studies have been focused on the primary questions like 53.7% studies are of home range estimation, 47.6% are of migration and movement pattern and 28.1% studies of habitat preference. Only a few recent studies have looked further at hibernation, den shifting, social organization and monitoring translocated and rehabilitated individuals; however, the number of such studies remains low till date (Habib *et al*., 2014).

Brief review of research work

Audet *et al*. (1991) in their research on foraging behavior of the Indian False Vampire Bat found out that the foraging areas of the radio tagged bats were located ≤500 m-4 km from the roost but 41% of the foraging activity occurred within 500 m distance from the roost. They also found that for both male and female individual flight ≥ 1 min were more common (69.7% and 72.5%, respectively) than flights < 1 min. Perching bouts lasted from < 1 min to 54 minutes for male and 274 minutes for females.

Hussain (1993) studied the mean river distance traveled by the radio implanted otters which was 5.3 km. The home range of all otters tracked overlapped extensively. Among them, the maximum home range was observed in Sub adult male (4.35 km^2) and the minimum in Juvenile male and juvenile female (2.13 km^2).

Karanth and Sunquist (2000) compared the activity patterns of radio collared tigers with leopards and revealed that generally leopards are relatively more diurnal than tigers. Their activity patterns may be explained by the fact that leopards kill a relatively greater proportion of diurnal prey species such as langur and chital. Leopard activity patterns do not suggest any active behavioral avoidance of tigers by hunting at different times of the day. Home range of tiger through Adaptive Kernel 95% ranged from 18.1 km^2 to 98.8 km^2, through Minimum Convex Polygon 95% ranged from 16.5 km^2 to 57.8 km^2 and from harmonic mean 95% ranged from 12.2 km^2 to 76.4km^2. Mean home range of leopard through Adaptive Kernel 95% was 28.2 km^2, through Minimum Convex Polygon 95% was 21.7 km^2 and through harmonic mean 95% was 28 km^2. Home range of Dhole pack through Adaptive Kernel 95% was 27.5 km^2, through Minimum Convex Polygon 95% was 23.4 km^2 and from harmonic mean 95% was 27.4 km^2.

Iqubal *et al.* (2003) found that the mean range size of swamp francolin was 1050 m^2. Male home ranges (1396 m^2) averaged larger than female's (822 m^2). Tall sugarcane and grassland appear to be the most favored habitats at the study area home range level; water bodies

and marsh were least favored. At the home range radio location level seasonal water bodies and grassland appear to be most favored and marsh and short sugarcane least preferred.

Venkatraman *et al*. (2005) investigated the use of satellite telemetry to mitigate human-elephant conflicts in West Bengal. They found out that of the total locations, the highest percentage of locations were in Sal plantations and dry deciduous forests. The lowest percentage was in evergreen forests and cultivated lands outside the park boundary. Of the total usable locations, 182 (47.4%) were recorded at night (1800-0600 hrs) and 202 (52.6%) during the day.

Jhala *et al*. (2009) studied the home range and habitat preference of collared female lions in Gir forest of Gujarat. They found that lionesses had an average 100% Minimum Convex Polygon home range of 48.2 km^2, 95% Minimum Convex Polygon home range of 34.7 km^2 and 95% kernel home range of 32.5 km^2. Overall, the lionesses were found to use Teak-Acacia-Zizyphus-Anogeissus habitat the most and the agricultural areas the least. During day time the most used habitat was Teak-Acacia-Zizyphus-Anogeissus habitat followed by the moist mixed forest type. Lions were not observed in agricultural fields during the day. During night, lions were found using Teak-Acacia-Zizyphus-Anogeissus habitat the most and even ventured into agricultural fields. The Teak-Acacia-Zizyphus-Anogeissus habitat type also had the maximum extent comprising over 40% of Gir.

Acharya *et al*. (2010) found that the home ranges of the radio-collared Dholes in Pench tiger reserve ranged from 66.4 km^2 to 202.8 km^2 (95% Minimum Convex Polygon). The maximum range width averaged 20.18 km (range 11.15-27.78 km). The seasonal home range size averaged 77.58 km^2 (±26.6 SE; n = 6 seasons) (95% Minimum Convex Polygon). The monthly range sizes of the radio-collared Dholes ranged from a minimum of 1.5km^2 to a maximum of 92.6 km^2. On average, the monthly ranges covered around 38 km^2. In all, 204 sequences of consecutive days of locating the three radio-collared Dholes were analyzed. The mean daily distance (inter-day distance) moved by Dholes was 2.96 km (± 0.16 SE). From the 32 continuous sessions of radio-tracking of the three Dhole packs, the mean distance moved over a 24 hour period (intra-day distance) by Dhole packs was found to be 6.54 km (±0.66 SE), with the maximum distance travelled within a day being 15.63 km.

Athreya *et al*. (2010) fitted Vectronics (GPS PLUS) collars on five leopards (3 males and 2 females) of Ahmednagar district of Maharashtra to understand the leopard movement in human dominated landscapes. They could fetch 633, 2430, 3674, 2213 and 3 locations of these leopards.

The preliminary result of this study indicate that the telemetry method provide sufficient data to reveal the seasonal resident patterns of the Chambal Gharial in some detail. The major findings were; each Gharial displayed it's on individual spatial preference for specific areas of the river stretch, activity centres and home ranges varied seasonally, the primary direction of movement was downstream during monsoon and upstream post monsoon, significant individual differences were evident as variation of the general pattern common to all. However, the study results were limited because; the 2009 monsoon was late and did not result in the usual high water levels and the absence of larger Gharial limited the findings to the 2 to 3.3 m residents only (Lang and Whitaker, 2010).

Barve *et al*. (2013) in their preliminary study on translocation of rescued King Cobras found that the 95% AK home range of King Cobra (M1) was more than five times greater than that of the other two snakes (M2 and M4).

Behera *et al*. (2018) studied the movements of Olive Ridley Turtles in Bay of Bengal. They found that Olive Ridley Turtle individuals travel at a mean speed of 2.49±0.02 km/hr; mean total distance travelled comes to 5185 km and mean total displacement is of 770 km, respectively.

Kumar *et al.* (2020) found the migration tracks of kites. There was no evidence of kites migrating by night. Pre-breeding and post-breeding migrations largely overlapped: kites crossed the Himalayas in its Western portion (Trans-Himalayas), traversed or circumvented the Taklamakan Desert of the Xinjiang Province and the Tian Shan Mountain Range of China, ending up in a wide region centered on the Altai Mountain Range at the intersection of Western Kazakhstan, Southern-Central Russia, Western Mongolia and North-Western China. In three cases (one North bound and two Southbound migrations), kites took an even more West ward route which brought them to the same destination through Eastern Pakistan, Afghanistan, Tajikistan and Kyrgyzstan. Overall, the tagged kites travelled relatively fast, completing a 3300–4800 km journey in 13–47 days, progressing on average by 150–240 km/day, with significantly faster speeds in the pre-breeding migration. The studies have also given adequate information on new migratory routes of Kites.

Conclusion

Radio telemetry has been a successful tool in studying the foraging behavior and activity packaging in Indian False Vampire Bat. It has also eased the study of movement pattern and home range of smooth coated otters. It has been used to understand Human-elephant conflict by the study of movement pattern and habitat utilization. Radio tagging the predators of Nagarhole forest gave significant results of activity pattern and home range of tigers, leopards and Dholes. Estimating the home range and habitat use of swamp francolin was enabled by radio implanting. It has been a key tool in studying the home range and habitat preference of female lions. The study of home range and movement pattern of Dhole was facilitated by the technology of radio telemetry. GPS-GSM collars made understanding of leopard movement in human dominated landscape easier. Knowing the activity centres and home range of Gharial was enabled by radio tracking. The potentially deleterious effects of long distance translocation on rescued king cobras were described by estimating their movement pattern and home range characteristics by radio tracking. Migratory roots and movement pattern of Olive Ridley Turtles was determined via satellite telemetry. The migratory routes of black eared kites were unraveled using this advancement of remote sensing and GIS.

Based on the literature reviewed, it can be postulated that telemetry has a key role to play in investigating ecology, behavior and conservation prospects of wild animals. The fundamental issue in any invasive research is the criticality of the information proposed to be collected and its relevance to the overall conservation of the species. It was also observed that a large amount of data is either missing or there is a reservation among the researchers to share the data. In view of

the rapid development of radio-telemetry tools, managers and researchers should have easy access to the performance parameters of the new tools to enable them to choose appropriate devices for their study.

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Seminar No. 9

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BANNI GRASSLAND: PAST, PRESENT AND FUTURE PERSPECTIVE

Introduction

Grasslands are one of the world's most extensive terrestrial ecosystems (Ali *et al*., 2016). It is considered as a playground for crucial interplay of complex ecological interactions. These land use systems harboring a number of threatened species are rapidly disappearing ecosystems (Bawa *et al.*, 2004). Grasses and their value to human beings have been recognized since time immemorial. About 80% of the grasslands of India are categorized as "poor" (GoI, 2007). In India, grasslands occupy in an area of 5,48,850 km2, covering 16.60% of countries geographical area (GOI, 2007). In Gujarat, there are two important grassland regions (GUIDE, 2004) - 1). Banni grassland (BG) and 2). Naliya. The Banni grassland, once known as Asia's best tropical grassland (Bharwada and Mahajan, 2012) spans an area of approximately 2,500 km2. The anthropogenic intervention stops the annual flushing of salt from BG which leads to drastic degradation. The rainfall is extremely erratic and variable in distribution. Severe droughts and reduced fodder production in BG leads the migration of maldharis to sustain the cattle herd. There is great need of conservation and restoration efforts to arrest further degradation of this important ecosystem for future generations.

Review of literature

Banni was declared a 'Protected Forest' under section 29 of the Indian Forest Act (FCA), 1927, under the former Kachchh Government Notification No. HR/155/55 dated 11-5-1955, with an intention to manage the area under the jurisdiction of the State Revenue Department (Kumar *et al.*, 2015).

Koladiya *et al*. (2016) studied avifaunal composition of birds in BG and recorded a total of 262 species of birds. According to the Indian Wildlife (Protection) Act, 1972, 3 of the bird species are recorded under Part-III of Schedule-I, and the remaining 259 species fall under Schedule- IV.

Kumar *et al.* (1998) studied faunal diversity of BG. The wild animals of Banni included blue bull, chinkara, black buck, backnaped hare, wild boar, jackal, grey wolf, caracal, striped hyena, fox and jungle cat.

Pillai *et al.* (2017) studied mid-late holocene vegetation response to climatic drivers and biotic disturbances in the Banni grasslands and reported that vegetation in the Banni was composed mostly of C3 vegetation from 4600 to 2500 cal yr BP (calculated year before present), after which there was a decline in C3 vegetation.

Kumar *et al.* (2015) studied floral diversity of BG and revealed that there are at least 192 species of vascular plants in these grasslands belonging to 142 genera and 50 families in BG.

Patel *et al.* (2012) studied the density (D), abundance (A), and IVI value of tree species among various habitats in western Kachchh, Gujarat and a total of 13 trees species were recorded. *Acacia senegal* and *Prosopis juliflora* were the most dominant and well distributed within all habitats.

Recently, Thorat *et al.* (2019) have recorded 41 grass species in this ecosystem.

Gajera and Koladiya (2019) studied mammalian species distribution and diversity in arid region of Kachchh, Gujarat. Based on direct sightings and indirect evidences, a total of 20 mammal species belonging to 11 families and 16 genera were recorded.

Ranjitsinh and Jhala (2010) studied herbivore pellet densities in BG and estimated higher livestock dung density of 6091 ± 297 dung piles/ ha. Sheep, goat and camel pellet densities were also high indicating that livestock grazing in this region is common. Wild herbivore pellets were very few, with nilgai being the most frequent (396/ ha ± 172), followed by chinkara (316/ ha ± 249).

Koladiya *et al.* (2014) recorded highest mean population density of birds in Prosopis-Capparis (15.9 individuals/km2), while lowest recorded in sparse Prosopis habitat (9 individuals/km2). It was found that, Prosopis-Salvadora (23.10±9.47) was the densest and Prosopis-Capparis (8.84±5.26) was the least dense habitat for common birds of BG.

Kumar *et al.* (2015) estimated the livelihood resource dependency by local people around BG and found that 43.70% people depend on grassland followed by 27.80% (animal husbandry), 15.80% (agriculture) and 15.50 % (fisheries).

Manjunatha *et al.* (2019) studied source of livelihood opportunities in BG at village level (n=280). Buffalo based rearing was the primary occupations and charcoal production was the predominant secondary occupation. Sheep and goat rearing, handicrafts production, services and trade were the other occupations for few households.

Shah *et al*. (2010) studied the livestock fodder requirement for Bhitara panchayat and calculated that daily requirement for total cattle was 33,489 kg (36.91 ton) and total yearly requirement was 40,18,671 kg (4429.82 ton).

Das *et al.* (2018) conducted satellite data based natural resources mapping of BG and located 94 water bodies from 21 village panchayat areas.

Sharma *et al.* (2004) reported that under various schemes of state as well as central government, the rivers were dammed between 60s and 70s, reducing the flow of fresh water into Banni area and due to the reduced flushing of surface salinity with the flow of water, the salinity levels in Banni has increased.

Kumar *et al.* (2015) studied the temporal changes of major land use classes in BG. They reported dominance of *P. juliflora* (86,569 ha) and a comparative analysis showed that during 1997 it occupied about 6.16% of the total area which increased to 33.07 % in 2009. Moreover, decrease in the *P. juliflora* with other vegetation by 74,012 ha. has indicated an aggressive encroachment of *P. juliflora* with the decline of native flora.

Munmun Sinha *et al*. (2014) evaluated land cover changes in BG using GIS and RS and concluded that 67,167 ha (25.70%) land cover has been converted to barren land from 1989-2008.

Manjunatha *et al.* (2019) studied absolute change in population of livestock species in BG and concluded that the population growth rate of Banni buffaloes (457.00%) was six times higher than the Kankrej cows (70.00%) from 1977 to 2012.

Sharma *et al.* (2004) found that maldharis with buffalo herd of more than 50 migrate to other areas, as a measure to cope up with drought to sustain livestock. while those with smaller herd size and capacity to purchase grass only stay back.

Kumar *et al.* (1998) advocated that different scientific approaches can be adopted for eco-restoration and their effects were promising than control.

Dayal *et al.* (2009) studied germplasm evaluation of different range grasses at regional research station, Kukma-Bhuj. Gemlplasm accession CAZRI- BH-CS-5 of *Cenchrus setigerus* and CAZRI- BH-DA-3 of *Dichanthium annulatum* performed better in respect of all parameters.

Sharma *et al.* (2004) carried out cost benefits analysis of regulating *P. juliflora* (regulated and un-regulated) in BG. Considering the cost-benefit in both the cases, regulating Prosopis turns out to be more beneficial.

Conclusion

The BG of Kuchchh district Gujarat is a unique ecosystem. It is very much important for the survival of local people with their livestock and harbor many floral and faunal diversity. It is a crucial ecosystem for the tribal herdsmen community. Degradation of BG inquisition the survival of domestic and wild animals. The constructions of dams during 1960, overgrazing, increasing human and livestock pressure, spread of *P. Juliflora etc*. have resulted in degradation of natural resource in BG. BG have potential to sustain human and wildlife population, hence its restoration through various management techniques (*in situ* water conservation, scientific management of grazing, arresting salinity, invasive species spread, reducing unpalatable species density, introduction of improved grass strains) and law enforcement could lead to increased carrying capacity for livestock and better conditions for other flora and fauna.

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Seminar No. 10

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ETHNIC FOOD CULTURE AMONG FOREST DWELLING COMMUNITIES OF WESTERN INDIA

Introduction

Ethnic foods are originating from a heritage and culture of an ethnic group who use their knowledge of local ingredients of plants and/or animal sources (Kwon,2015).Ethnic people mostly the indigenous tribes live close in the vicinity of forests and have managed and conserved the biodiversity of their localities since long time. Western part of India includesfour States (Rajasthan, Gujarat, Maharashtra and Goa) andtwo Union Territories (Daman and Diu, Dadra and Nagar Haveli) and coordinates 23.9074° N, 72.7097° E. Major Ethnic communities of this area are Bhil, Meena, Chaudhari, Warli, Kokna, Gond andKathodia with the state of Maharashtra having highest ethnic tribe (47 ethnic groups).The communities use their knowledge to prepare food from different plants called ethnic food. They eat this food as an emergency food for fighting hunger and malnutrition.Nowadays these are thesupplementary food for livelihood and medicinal purpose. The various wild food sources are tree-based food, tuber crops, leafy vegetables, fruit crops, bulb, pods, seeds, nuts, mushroom many more. Attempt made here to put a light on ethnic food culture among forest dwelling communities of Western India.

Brief review of research work

Lalita *et al.* (2009) studied the food system of Bhil community related to food security, nutrition and health in Dang district of Gujarat and they reported the use of total 95 ethnic food items. Study highlighted the use of variety of wild plants and local fish with preparation and processing methods unique to the Bhil culture. They also studied nutrient composition of Bhil tribesand their dietary assessments for women and children. Several micronutrient rich traditional foods were also frequently consumed by the people.

Sonali *et al*. (2018) carried out the study in Gujarat on consumption pattern of wild edibles by the Vasavas. Study showed that, anthropologically managed habitatswere preferred

over natural environments for the collection of wild edibles. Further, they suggested that, conservation effortsshould be extended to village landscapes in addition to human uninhabited landscapes. A wide range of wild edibles, tree species are likely playing an importantrole in the acquisition of micronutrients, as they canprovide sustenance throughout the dry period.

Shalini (2016) had reported that, the wild fruits of Kutch include jungle jalebi, Karonda, Gundi, Ker,Rasbhari, Rayan and Khajur.Fruitsof Karonda, Gundi and Ker are used for pickle, Phalsa used for preparation of sherbets andJungle jalebi for chutney making.

Suwarna and Kulkarni (2013) stated that, *Theriophonum indicum* a wild vegetable consumed by the Gondia tribe of Vidarbha region of Maharashtra,further they reported the leaves were also consumed with appropriate method to remove its irritating substances.

Suwarna *etal*. (2015) documented total 73 wild food resources belonging to 42 families were consumed by Rajgond tribe of Vidarbha region of Maharashtra. The documentation includesthe name and parts used as a source of food and their food system.

Devarkar (2018) carried out inventory for ethno-vegetable knowledge of the tribal people from Satpura hill area of Melghat, Maharashtra.They found total 30 species belonging to 20 genera and 17 familieswere usage in their food system. Majority of ethno-vegetable plants were herbs and they are used mainly by Korku tribeswhereas other tribes like Gond, Nihal, Balais, Gaolis and Gaolans rarely utilize these resource.Study strongly suggested that, the traditional knowledge is to be transferred properly by old people to the younger generation and should be trained in collection and processing of such wild ethno-vegetables.

Satvi and Marathe (2018) described from their study that, 30 species of wild edible plants were being used as a food source by rural communities of Palghar district of Maharashtra. Study revealed the use of leaves of 12 species, rhizome of 03 species, fruits of 07 species and other part of 08 species. It was found that, whole plant or its part consumed either directly or after cooking.

Ashwini *et al*. (2014) mentioned about the consumption of wild fruit resources like Bhokar, Kakad, Aliv and Pendhra by the tribal people from Jawharregion of Thane district Maharashtra.Study is helpful in reporting about the traditional way of processing methods practiced by the tribal communitieswith respect to preservation and value addition processes.

Gawali and Narkhede (2018) documented the diversity of wild vegetables in forest of Konkan region of Maharashtra. They documented 58 wild edible plant species belonging to 27 families.Herbs were dominating (41%) followed by climbers (40%), trees (15%) and shrubs (4%). Out of these species used as, 47% were leafy vegetables, 28% fruit, 22% stemspecies, 8% inflorescence and flower speciesand 5% species as a whole plant.The study advocatedthe urgent need of documenting the traditional knowledge related to the intangible cultural heritage concerning wild edibles.It is strongly suggested that, the conservation, utilization and domestication of these wild food resources should be promoted to maintain the dietary needs of the households in the Konkan region of Maharashtra.

Swapnaja *et al.* (2019) carried out survey and documented food potentialsand importance of wild edible plants consumed by rural peoplein theSatara district, Maharashtra. Total 90 plants were recorded belonging to 46 families and 73 genera. The edible part of these species includes

rhizomes, corms, stem, leaves, petiole, inflorescence, flowers, petal, thalamus, fruits, seeds and aril.

Lohar and Arora (2018) documented the functional fruits for their pharmacological properties. Ethno-medicinal survey of southern Rajasthan reveals the usage of 50 functional fruits plantsfor their pharmacological properties. Among these,15 fruits are used in diabetes, 11 in digestive disorders and 04 in respiratory ailments. Alsoreported about the use of grains and seeds utilized for making bread by the tribal communities of southern Rajasthan.

Kamat (2017) stated about the presence of 100 different species of edible mushrooms in Goa and considerable amount of which are collected from the wild by the local tribes. He also found that, *Termitomyces genus* (olmi) mushroom harvested from termite mounds in Goan forests is important one and have lots of demand.Unfortunately, it has been difficult to grow them in artificial conditions, and as a result olmis are now threatened by overharvesting. In fact, a lot of mushroom varieties in this region are vulnerable.

Parab (2017) reported the wild vegetables seen in various markets of Goa. It includes thewild vegetables like *Cassia tora* (Taikalo), *Colocasia esculenta* (Tere or Tero) and *Celosia argentea* (Kuddu) but commonly eaten as edible part of Taikalo plucked from a clean patch of landby the Goans.

Conclusion

Major ethnic communities of western India are Bhil, Meena, Chaudhari, Warli, Kokna, Gond, Kathodia. Maharashtra having highest number of ethnic tribal communities (47) followed by Gujarat (29), Rajasthan (12), Goa (9) and least in case of Daman andDiu (5). The various wild food sources used are tree-based food, tuber crops, leafy vegetables, fruit crops, bulb, pods, seeds, nuts and mushroom. Among these, leafy vegetables and fruits are widely consumed by the tribal communities, but the consumption pattern vary according to theseason and availability.These ethnic foods are functional ingredients and lead to improve the health in a holistic way. Most of the forest dwelling communities practice this healthy food system and which are the integral part of their traditional way of lifestyle. Majority of the literatures reported about the diminishing of ethnic food culture in recent time even among tribal communities. It is declined due to many reasons like unavailability, deforestation, over-harvesting, indiscriminate way of utilization, change in food preference & socio-culture, modern lifestyle *etc*. Another major concern is lessening traditional knowledge among youths of forest dwelling communities needed to identify edible species in wild. Synergetic efforts are very essential to conserve these wildresources which are crucial to fighting hunger and malnutrition, to supply medicines and ultimately to provide sustainable livelihood option for needy people. Safeguarding the ethnic food culture will be helpful for protecting the traditional way of lifestyle and diversity among the forest dwelling communities.

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Seminar No. 11

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TREE ROOT DYNAMICS IN AGROFORESTRY

Introduction

Root dynamics are the changes that taken place in root growth and architecture over a period of time. Parameters such as length, number, mass, architecture, diameter and angle of rooting are used in root dynamic studies. Root dynamics influence the fluxes of water, carbon, soil nutrients, and the distribution and activity of soil fauna. Tree roots add multiple benefits in agroforestry systems like N_2 fixation, reduction of nutrient leaching, prevention of soil erosion, addition of biomass, *etc*. Tree root architecture and distribution decides the complementary effect with agriculture crops. Tree root production and distribution in agroforestry is influenced by many internal as well as climatic, edaphic and biotic factors. Some above ground management practices also influence the tree root dynamics and ultimately useful for success of agroforestry.

Review of literature

Variation in root production at different spatial distance from the stem

Dhyani and Tripathi (2000) reported that *Citrus reticulata* has more horizontal root length and straight path extent *i.e*., 109.7 cm and 79.2 cm, respectively; whereas, *Paraserianthes falcataria* and *Alnus nepalensis* were found to have less horizontal root length (77 cm) and straight path extent (55 cm), respectively in agrisilviculture system of North East India.

Raz-Yaseef *et al*. (2013) analysed the root biomass of trees in six different sites of oak grass savanna (Silvipastoral system) with varying soil depth and distance from the tree bole. They reported that 50 per cent of the root biomass exists in all the sites within the top 20 cm of the soil profile and lateral distance of 1.3 m.

Swamy *et al.* (2003) documented that highest biomass of total course roots (1.419 Mg ha^{-1}), fine roots (0.49 Mg ha^{-1}) and total roots (1.909 Mg ha^{-1}) was found in the 2m x 2m spacing of *Gmelina arborea* (4 years old) intercropped with soybean, with low average tree root spread (0.38 m). High root: shoot ratio (0.67), average root spread (0.98 m), crop yield (2.1 Mg ha^{-1}) were observed in 2m x 5m spacing.

Root growth variation among different species

Verma *et al.* (2014) reported highest root depth (4.78 m) and less lateral spread (1.1 m) in *Bauhinia variegata,* whereas highest maximum lateral root spread (7.33 m), root biomass (6.3 kg $tree^{-1}$), angle between primary-secondary roots (85.39°) in *Robinia pseudoacacia* among the 6 different studied multi-purpose tree species of Western Himalayas.

Borden *et al.* (2016) concluded that *Picea abies* has more fine root length density within top 10 cm of soil profile, followed by *Populus deltoides x nigra* DN177 whereas, it was reverse in 10 to 20 cm depth of soil.

George *et al.* (1996) found that *Leucaena leucocephala* and *Ailanthus triphysa* had uniform root distribution of active roots at lateral distances of both 25 cm and 50 cm in silvipasture system; while *Casuarina equisetifolia* and *A. triphysa* have doubled the root activity in 15 cm soil depth as compared to the subsurface layer (50 cm) of the soil. Moreover, more root activity with little variation was noticed at 15 cm and 50 cm soil depth respectively in *Acacia auriculiformis* and *L. leucocephala*.

Gei and Powers (2014) reported that plantation of fast growing species (*Gliricidia sepium, Enterolobium cyclocarpum, Leptolobium panamense*) had approximately 41 per cent more root biomass in the surface layer (0-15 cm) whereas slow growing species (*Dalbergia retusa*) exhibited 44.3 per cent more root biomass in the deeper layer (15- 30 cm).

Effect of season, age and nutrients on root production

Lehmann and Zech (1998) observed total root carbon of 485 kg C ha^{-1} to a depth of 120 cm in the alley cropping system of *Acacia saligna* with *Sorghum bicolor* during the wet season of the year, which was almost twice the total root carbon produced in the dry season (223 kg C ha^{-1} to a depth of 120 cm).

Germon *et al*. (2016) revealed that deep (>2.5 m) root growth of *Juglans regia* occurred at two distinct periods in spring (at bud break) and the winter (after leaf fall). In contrast, shallow roots grew mainly during the spring-summer period. Maximum root elongation rates ranged from 1 to 2 cm day^{-1} depending on soil depth.

Thakur *et al.* (2015) found maximum total root dry matter of 59.81 kg $tree^{-1}$ in the *Grevillea robusta* trees having >25 cm diameter class as compared to remaining lower diameter classes (5-15cm and 15-25cm).

Sun *et al.* (2015) reported that live/dead root ratio decreased significantly with stand age, *i.e.,* 3.5, 1.7, 1.4 and 1.1 ratios in the 20, 36, 57 and 82 year old stands, respectively.

Singh and Singh (2016) observed that fine root biomass of 95.7 g m^{-2} in poplar increased with increase in application of nutrients (625N:400P_2O_5) and also higher mean fine root biomass of 76.4 g m^{-2} was found in the month of October than in other months of a year.

Thang *et al*. (2020) revealed that more root production (10.4 tons ha^{-1} $year^{-1}$) and root mortality (8.75 tons ha^{-1} $year^{-1}$) were found in *Acacia mangium* treated with 0N:600P:100K fertilizer than other doses of nutrients.

Effect of canopy management on root growth

Kunhamu *et al*. (2009) found highest root activity of *Acacia mangium* in high stem density (2m x 1m spacing) within a radial distance of 25 cm from the base of the trees irrespective of depth; whereas in low density stands (4m x 2m), higher relative proportion of root activity was noted at a radial distance of 75 cm. Further, pruned low density stand had 34 per cent root activity as against 23 per cent for unpruned low density stand at 25 cm lateral distance.

Kaushal *et al*. (2017) found that majority of the *Morus alba* fine root biomass (67.3 per cent) was confined in 0-15 cm soil layer. Further, among different management treatments, maximum root depth (82.7 cm) found in pollarding with turmeric treatment and less root spread (3.27 m) in lopping with turmeric treatment in inter cropped plots as compared to non-intercropped.

Berhongaray *et al.* (2015) concluded that root production as well as mortality rate were increased in the post coppicing period of poplar trees of both Koster and Skado genotypes than in the pre coppicing period.

Conclusion

Tree root dynamics in agroforestry has a great significance towards its feasibility and production in general. Overall study showed that maximum active roots in agroforestry trees distributed within 30 cm of depth and the lateral spread of active roots varies with species, age and its management practices. Further, fast growing tree species accumulate more roots near the soil surface whereas slow growing species accumulate biomass almost uniformly throughout its vertical length while root activity in wet season is more than the dry season. Study shows that among different fertilizers, Phosphorus fertiliser largely influences the root production of trees in agroforestry. Tree management practices such as lopping and pruning with wider spacing in agroforestry have direct impact on fine root distribution; hence, it should be judiciously managed for avoiding competition in intercropping situation. Therefore, it is concluded that, tree root dynamics in terms of root spread, number, diameter, biomass *etc*. in agroforestry can be managed or manipulated for its greater prospective.

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Seminar No. 12

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DNA BARCODING FOR DETECTION OF ADULTERATION IN MEDICINAL PLANTS

Introduction

Adulteration is a practice of substituting the original crude drug partially or fully with other substances which is either free from or inferior in therapeutic and chemical properties or addition of low grade or spoiled drugs or entirely different drug similar to that of original drug substituted with an intention of enhancement of profits (Kokate *et.al.,* 2007). At the global level survey, it has been reported that overall, 27% of all herbal products from the global marketplace are adulterated. The proportion of adulterated products varies significantly among continents, being highest in Australia (79%) and lowest in Asia (23%).

Whereas in India the adulteration was found up to 31% (Icham, 2019).It poses a great effect on both safety and health of the consumer (Srirama *et.al.* 2017). In the recent years, DNA barcoding has developed as a novel method for detecting adulteration in medicinal plants across the globe (Yu *et al.,* 2021). It is a type of technology in which a standard, short DNA sequence used as marker called DNA barcode, for rapid, accurate, and automatic species identification (Hebert and Gregory, 2005).

Brief review of Research Work:

Traditional DNA barcoding techniques

Srirama *et al.* (2010) calculated the percent inter and intra-specific divergences among three *Phyllanthus* species (*P. amarus*, *P. tenellus* and *P. polyphyllus*) using *matK, psbA-trnH* and *trnE-trnF*. They reported that *psbA-trnH* showed a significant difference between the inter and intra-specific divergences. They further reported that market samples of *Phyllanthus* sold in southern India contain at leastsix different species and among them, *P. amarus* is predominant. DNA barcode, *psbA-trnH* effectively discriminate *Phyllanthus* species and hence can be used to resolvespecies admixtures in the raw drug trade of *Phyllanthus* in South India.

Purushothaman *et al.* (2014) analyzed the percentage of divergence and species discrimination based on pairwise alignment of *matK, rbcL, trnH-psbA* and *ITS2* markers for *Cassia* species in Tamil Nadu (India).They found that *rbcL + trnH-psbA* showed 100% species discrimination. They further validated their results through multivariate analysis using NMS (Non metric Multidimensional Scaling) which clearly showed that tiered barcode i.e. *rbcL + trnH-psbA* is the most promising barcode for authentication of *Cassia* medicinal products.

Kumar *et al.* (2015) evaluated three DNA barcode markers i.e. *psbA-trnH*, *matK* and *ITS2* for accessing species adulteration in raw drug trade of Bala (*Sida* spp.) in South India. They observed that both *ITS2* and *psbA-trnH* regions showed significant differences between inter specific and intra-specific divergences. Thus, they used both *ITS2* and *psbA-trnH* to identify the ingredients in raw *Sida* herbal products obtained from 10 markets in Southern India. They indicated that species adulteration in the market samples is rampant especially in case of *Sida cordifolia*, where all the market samples analyzed were *Sida acuta*.

Yang *et al.* (2011) reported the *psbA-trnH* as a potential DNA barcode for detecting *Valeriana jatamansi* J. as an adulterant in medicinal *Paris* (*P. polyphylla* var. *chinensis* and *P. polyphylla* var. *yunnanensis).*They found that the DNA sequences length is >1000 bp in medicinal *Paris* and around 250 bp in *V.jatamansi.*

Sheidai *et. al.* (2019) tested the significance of *ITS* for detecting adulteration in medicinally important plant species of *Ziziphora* in several market products/samples in Iran. The results showed that all randomly studied market samples differ from true *Ziziphora* species.

Amritha *et al.* (2020) analysed 103 market samples of Ashwagandha in India and found

that 77% of samples were authentic and 22% of non-authentic samples were in the form of powder and only 1% were root samples. They further concluded that *trnH-psbA* barcode as a potential marker to detect adulteration in the market samples of Ashwagandha.The mixed sample showed multiple bands whereas authentic sample showed a single band during agarose gel electrophoresis.

Advanced DNA barcoding techniques

Urumarudappa *et al.* (2016) concluded a widespread adulteration in the in the raw herbal trade of *Saraca asoca* using DNA barcoding (using *rbcL* and *psbAtrnH* region) validated by NMR spectroscopic techniques. They found that only HAS 220 (from Kerala) was found to match with the authentic plant material, based on both DNA barcoding and NMR spectroscopic analysis. Whereas, HAS 405 and 375 did not match *S. asoca* genetically, but they share similar chemical profiles based on NMR results because in some samples peaks for many pharmacologically significant phenolic metabolites such as rutin, hesperidin, naringenin, and caffeic acid were observed and absent in others.

Abubakar *et al.* (2018) assessed the extent of adulteration in *Eurycoma longifolia* herbal medicinal products (HMPs) using DNA barcoding (using *rbcL* and *ITS2* marker), validated by HPLC analysis.They found that based on DNA barcoding four HMPs (TAP-1, TAP-3, TAP-6 and TAP-8) were authentic while three (TAP-4, TAP-5 and TAP-7) were adulterated. Whereas, based on HPLC validation only three HMPs i.e.TAP-1, TAP-8 and TAP-3 had the eurycomanone level 0.2%, 0.5% and 0.7% respectively.

Mishra *et al.* (2016) reported *ITS1* as successful barcode to discriminate among the different *Senna* species for detecting adulteration HSA01 (*S. alexandrina* crude drug sample from Bangalore) and HSA06 (*S. alexandrina* crude drug sample from Tuticorin, Tamil Nadu, India) were found to be highly contaminated with *S. italica* subsp. *micrantha*. Whereas, HSA01, 02, 08 and 09 were the putative *S. alexandrina* species. They further validated the adulteration using High Resolution Melting (HRM) which clearly indicated different curves for different percentage of contamination or substitute species in commercial samples.

Conclusion

DNA barcoding is a widely accepted and has played an important role in the identification of adulterants, and the regulation of the pharmaceutical market.The *matK*, *rbcL*, *psbA-trnH* and *ITS2* has been identified as the potential DNA barcode markers for detecting adulteration in medicinal plants. In the recent years several advance technologies such as NRM spectroscopy, Bar-HRM (High Resolution Melting), HPLC in accordance with the DNA barcoding has accelerated the authentication in medicinal plants. Thus, it plays an important role in detecting adulteration of herbal products derived from traditional medicine, and to increase consumer confidence by advocating and promoting a higher standard of quality in medicinal plants.

Future Thrust

In fine processing products, (e.g. tablets, pills, oral liquids and injections, etc), there is

still lack of effective, rapid, and standardized identification methods up to now, especially for the complex botanical components of the Chinese patent medicine. Thus, the technology has a broad application prospect in the field of medicinal plants, and it will certainly help the modernization of traditional medicines in countries around the world.

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Seminar No. 13

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EFFICACY OF MICRO IRRIGATION IN FOREST TREE SPECIES

Introduction

India is facing huge problem of water scarcity. The best possible way to conserve water in a developing country like India is the judicious use of water in irrigation and that by moving towards micro irrigation systems. Micro irrigation is the frequent application of small quantities of water near the plant root zone consequently giving multiple benefits over conventional irrigation systems. The use of micro irrigation systems in forestry is restricted only towards forest nurseries and some commercial tree crops. The most common type of micro irrigation systems used in forestry includes drip irrigation, sprinkler irrigation, bubbler irrigation and buried clay pot irrigation systems.

Brief review of Research Work

Efficiency of irrigation in trees

Hunter (2001) studied the effect of irrigation on above ground biomass on three tree species of one year old viz. *Eucalyptus camaldulensis, Eucalyptus grandis*and *Dalbergiasissoo.* Irrigation has significant impact on the dry weight of the tree species. With irrigation rate of 7.5 mm/day the maximum dry weight response was shown by the two *Eucalyptus* species followed by *Dalbergia sissoo.* Irrigation increased the dry weight linearly across the treatments.

Bilas and Genda (2004) studied the effect of water stress on the tree growth parameters, total biomass, root nodule number and nodule biomass of 9 months old seedlings of *Dalbergia sissoo*. The irrigation levels were 20mm (W1), 14 mm(W2),10 mm (W3), 8mm (W4)and no further water was added to the containers after saturation at field capacity initially (W5). They concluded that the treatment (W1) showed higher value for all the parameters measured indicating the importance of optimum levels ofirrigation.

Sneha *et al.* (2012) concluded that sufficient irrigation levels (IW/ET=0.6 and IW/ET=1) on six months old seedlings of Teak (*Tectona grandis* L. f.) was sufficient to meet the water requirements and showed highest values for the biometric and physiological parameters.

Efficiency of Microirrigation in trees

Wei *et al.* (2008) studied the form and distribution of root under normal irrigation and sub- surface drip irrigation in poplar trees. The subsurface drip system increases the total root biomass, total skeleton roots as well as the total number of absorbing roots as compared to the normal irrigation system.

Shrivastava *et al*. (2010) evaluated the performance of pitcher irrigation on young mango crop and concluded that the treatment T2 with only 14L of water per week resultedas second best treatment in growth with 30% less cost of irrigation and 30% water saving as compared to control and so suggested to consider T2 as the best treatment.

Oliveira *et al*. (2013) studied the performance of two *Eucalyptus* hybrids under dripping system, micro sprinkler and dryland condition. They found that evapotranspiration under micro sprinkler (397.95 mm) was high as compared to dripping system (320.89 mm) indicating that more area was wet by this system. Further, the irrigation depth was more in micro sprinkler indicating more water supplies as compared to dripping and dryland condition. Again, maximum biometric characters of *Eucalyptus* hybrids were achieved in micro sprinkler system.

Zubair *et al.* (2014) studied the biometric parameters in three species namely *Syzygium cumini, Dalbergia sissoo* and *Morus alba* under drip, bubbler and flood irrigation system. They found that in all the tree species the bubbler system and drip irrigation system remained significant in producing shoot fresh weight, root fresh weight, shoot dry weight and root dry weight over conventional flooding system.

Soothar *et al*. (2015) studied the performance of bubbler irrigation system. They calculated the values of coefficient of variation, uniformity coefficient and discharge uniformity and found that the water application uniformity was satisfactory under entire system.

El-Gindy *et al*. (2016) studied the influence of different irrigation system techniques on growth parameters such as total height and root collar diameter (RCD) for *Tectona grandis, Khaya senegalensis* and *Gmelina arborea*. They revealed that maximum RCD for three tree species and total height for *T. grandis* and *G. arborea* were recorded in bubbler irrigation system whereas in drip irrigation system total height was found maximum in *K. senegalensis.*

Balasubramanian *et al*. (2017) studied the growth performance of *Neolamarckia cadamba*, *Acrocarpus fraxinifolius* and *Dalbergia sissoo* under drip irrigation for 12 months after planting. Among the three tree species, *N. cadamba*exhibited maximum height of 4.40 m, basal diameter of 5.31 cm and DBH (Diameter at Breast Height) of 5.03 cm followed by *A. fraxinifolius* (height of 3.99 m, basal diameter of 4.52 cm and DBH of 4.26 cm) and

minimum in *D. sissoo* (height of 3.37 m, basal diameter of 3.45 cm and DBH of 3.96 cm).

Bueno *et al.* (2020) studied the variations of height and diameter as a function of total volume of water applied by means of drip for *Schizolobiumparahyba*, *Citharexylum myrianthum* and *Ceiba speciosa* seedlings. They found that there were positive responses of height (H) and collar diameter (D) as a function of the increase in water volumes applied to the seedlings of all species. *C. speciosa* seedlings had the highest growth rate in response to the amount of water applied.

Jagani *et al.* (2020) studied the effects of different levels of irrigation under drip irrigation system on *Melia composita.* Irrigation schedules of drip irrigation were based on IW/CPE ratio of 0.6, 0.8, 1.0 and 1.2. The biometric parameters such as height (4.81 m), collar diameter (8.27 cm), Girth at Breast Height (21.50 cm), leaf area (31.19 cm^2) , biomass (154 tonnes/ ha), water use efficiency (16.32 kg/ha-mm) and Benefit Cost Ratio (9.6) were found higher in treatment T4 (IW/CPE=1.2).

Conclusion

Forests play an important role in the country's economic development, environmental amelioration and climate change mitigation. Micro irrigation is the best choice towards water saving and judicious utilization for crop production. Presently there is very limited use of micro irrigation in valuable tree species, mainly because of its high initial investment and maintenance cost. From the review, it can be concluded that increase in irrigation levels through micro irrigation, amplify the growth of trees. Moreover, it enhances the total amount of skeleton roots, absorbing roots thus enhancing the productivity and is considered better as compared to conventional irrigation system for tree species. Again, drip as well as bubbler micro irrigation systems are more effective towards tree growth and development. Further, more studies have to be done for the development of the micro irrigation systems for increasing its applicability towards forest tree species.

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Seminar No. 14

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PROPAGATION TECHNIQUES OF MANGROVES IN INDIA

Introduction

Mangroves are the only trees amongst a relatively small group of halophytic higher plants that live in the intertidal zones at the interface between land and sea, and are well adapted to survive flooding and high salinity conditions. They are of great significance, both, in terms of their utilization in forestry and aquaculture, and their indirect potential in protecting coastlines and maintaining estuarine ecological balance. Due to several natural and anthropogenic pressures globally, these mangrove forests are being destroyed recklessly every year which called for a conservation strategy that can expedite the restoration of degraded areas at a faster pace. In the present day context of intensive afforestation and management of mangrove forestlands, it is

most important to develop fast and economically viable methods of raising superior stocks. Vegetative propagation provides an opportunity to harness and exploit genetic variations directly (Zobel and Talbert, 1984). The success of propagation techniques requires proper hormonal balance, temperature, rainfall, humidity, nature of media and light that collectively decides the status of regeneration of roots in cuttings (Dhua and Mitra, 1988). Although vegetative propagation is least expensive its success is still limited in mangroves.

Review of literature:

Propagation by seeds

De Silva and Amarasinghe (2013) observed that all the three mangrove species *viz. Rhizophora apiculata, Bruguiera sexangula* and *Ceriops tagal* showed their best germination percentage of 100 per cent, 60 per cent and 60 per cent, respectively in potting media consisting only Mangrove soil.

Downton (1982) found that seeds of *Avicennia marina* not exposed to salt (0 % sea water) took less time to undergo various developmental stages *viz.,* splitting away of pericarp from the embryo (2.2 days), followed by the separation of cotyledons (12.8 days) and emergence of shoot (18.8 days) as compared to other treatment combinations.

Propagation by cuttings

Chand and Kumar (2010) reported maximum rooting response (76.70 %) in the hypocotylar juvenile stem cuttings of *Aegiceras corniculatum* under treatment combination T2 *viz.* IBA (1 mg/l) + NAA (5 mg/l).

Thatoi *et al.* (2001) noticed that IAA (500 mg/l) recorded maximum sprouting percentage (70 %) meanwhile IBA (1000 mg/l) recorded both maximum rooting percentage (40 %) and root length (5.5 cm) whereas maximum mean root number was found to be compatible in various treatments in cuttings of *Intsia bijuga*.

Eganathan *et al.* (2000) concluded that for cuttings of *Heritiera fomes* treated with IBA (2500 mg/l) maximum percentage of rooting (55 %) and number of average roots (5.6) were observed in the month of October.

Basak *et al.* (2000) studied the effect of auxin interactions on mean root number of girdled and non-girdled cuttings of five mangrove species *viz., Bruguiera parviflora, Thespesia populnea, Exoecaria agallocha, Heritiera fomes* and *Cynometra iripa* after 30 days of treatment and observed that the maximum mean root number in *B. parviflora* (4.20) *and T. populnea* (16.00) was reported in girdled cuttings treated with IAA (1000 mg/l) + IBA (1000 mg/l) and IAA (5000 mg/l) + IBA (5000 mg/l) respectively. However maximum mean root number in *E. agallocha* (26.00), *H. fomes* (24.80) and *C. iripa* (29.00) was recorded again in girdled cuttings treated with IBA (5000 mg/l) + NAA (2500 mg/l).

Das *et al.* (1997) observed that the stem cuttings of *Avicennia officinalis* gave highest percentage of rooting (50.5 %), root number (3.5), root length (2.1 cm) and survival percentage (55.5 %) when treated with a combination of IAA (1000 ppm)+ IBA (1000 ppm), whereas the stem cuttings of *Rhizophora mucronata* gave highest percentage of rooting (25.0 %), root

number (3.2), root length (2.1 cm) and survival percentage (46.6 per cent) when treated with combination of IBA (2500 ppm)+ NAA (5000 ppm).

Propagation by air layers

Perera *et al.* (2020) deliberated that air-layered branches of *Lumnitzera littorea* revealed maximum percentage (50 %) of root formation when applied with rooting media of coir dust soaked in normal Tap water and rooting media of coir dust soaked in Brackish water individually whereas minimum root formation (0 %) was observed in air-layered branches applied with rooting media of coir dust soaked in Distilled water + IBA treatment.

Eganathan *et al.* (2000) observed that the air layers of *Heritiera fomes* responded best to auxin treatment of IBA (2500 mg/l) by showing 55 per cent rooting and 5.6 average number of roots per cutting whereas mean root length was observed to be maximum (5.1 cm) in the air layers treated with auxin treatment of IBA (1500 mg/l). Further, they reported that *H. fomes* cuttings raised in the month of October revealed maximum percentage of rooting (55 %) and number of average roots (5.6).

Kathiresan (1995) reported that the significant effect of season on the air layers of *Sonneratia aptela* was distinguished only during monsoon (October-December) and post-monsoon (January-March) months with maximum air layers rooting in the month of October-December that were 12 out of 32 and minimum in Summer and Pre-monsoon seasons that were 0 out of 32.

Propagation by propagules

De Silva & Amarasinghe (2013) recorded maximum root elongation and survival percentage of *Rhizophora apiculata* in treatment consisting IBA (1000 ppm) and maximum shoot elongation in treatment consisting IBA (1500 ppm). Further, they deliberated shoot height of seedlings grown in different substrates and reported maximum shoot height in seedlings growing on substrates consisting Mangrove soil: sand (1:1).

Propagation by explants using tissue culture

Vartak and Shindikar (2008) documented maximum callus (87 %), sprouting (74 %) and rooting (74 %) in hypocotyl segments of *Bruguiera cylindrical* inoculated on MSM (Mineral salts medium) in controlled condition. Further, they compared the response of hypocotyls segments to MS (Murashige and Skoog medium) and MSM and deduced that MSM gives more significant results for callus, sprouting and rooting percentage as compared to MS medium. They further evaluated the comparative growth rates of micro-propagated plants and greenhouse grown plants of *B. cylindrica* and observed that the increase in height and number of nodes was comparable in both micro-propagated and greenhouse grown plants.

Al-Bahrany and Al-Khayri (2003) found that the explants of *Avicennia marina* showed maximum rooting percentage (100 %) and shoot length (28 mm) when the concentration of IBA was 0.5 mg/l in the rooting medium meanwhile maximum number of roots per shoot (2.2) and root length (15.4 mm) were observed when the concentration of IBA was 4 mg/l and 2 mg/l, respectively.

Rao *et al.* (1998) inferred that the growth rates for height when compared between seed-propagated and micro-propagated plants of *Excoecaria agallocha* raised from the same mother plant were compatible for both tissue culture-raised and seed-propagated plants, whereas the number of nodes was greater in the tissue culture-raised plants (11.8) as compared to that of the seed-propagated plants (8.5).

Conclusion

Mangrove soil is the best media for germination of seeds and propagules as well as for rooting of cuttings. Normal water is best for the early development of seedlings from seeds. Among different propagation methods, propagation by seeds is found to give more promising results followed by air-layering. Among different rooting hormones, IBA is found to be best for cuttings, air layers and in-vitro cultures but the optimum concentrations vary among species from IBA 1000 ppm to IBA 2500 ppm. Rooting response of cuttings of several species shows varying results when they are applied with combinations of different rooting hormones at different concentrations so it is difficult to generalize a particular combination of a particular concentration for all the mangrove species.The Hypocotylar-plus-stem (HpS) cuttings give better rooting percentage and mean number of roots as compared to juvenile-stem (JS) cuttings.Monsoon season particularly October month shows promising results in the root-shoot development of cuttings and air layers.When comparing growth rates between seed-propagated and micro-propagated plants of available mangrove species not much significant difference is reported.

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Seminar No. 15

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PRODUCTIONTECHNOLOGYOF*ANDROGRAPHISPANICULATA* (BURM. F.) NEES. (KALMEGH)

Introduction

Andrographis paniculata (Burm. f.) Wall. ex Nees (Family: Acanthaceae) is herbaceous plant that is extensively usedin traditional medicines. It is distributed in South Asian countries and is widely used as amedicine in India, China, Hong Kong, Philippines, Malaysia, Indonesia and Thailand. According to the Ayurvedic Pharmacopoeia of India, *A. paniculata* is included in 26 Ayurvedic compositions. It is a potential medicinal plant with multiple therapeutic valuesranging from curing an ordinary cold to lethal cancer. It is prominently employed in practically all East Asian, South Asianand South East Asian traditional system of medicines.

It possesses therapeutic properties like stomachic, hepato protective, dyspepsia, anthelmintic, bitter tonic and febrifuge.The market potential of *A. paniculata* is quite large, and its aerial components trade is predicted to be 250 tonnes peryear (Sharma *et al.*, 2008). It is the main source of the bitter principle andrographolide‟. Because of the extremelybitterand characteristic taste of *A. paniculata*, it is known as the "king of bitters". Besides andrographolide, this plant contains14-deoxy-11, 12- didehydroandrographolide-2, 14-deoxyandrographolide- 3, 3, 14 -deoxyandrographolide-4, 14-deoxy-11-oxoandrographolide-5, neoandrographolide-7, 14- deoxyandrographiside-95 in significant quantities (Kataky and Handique, 2010).

Brief review of research work

Kumari *et al.* (2012) discovered statistically significant differences in seed germination as a result of germination enhancing treatments. Among the different treatments, GA_3 (200 ppm) produced the highest germination rates (99.2 % and 88.3 %, respectively) in the CIM-Megha and wild varieties. In the Nursery test, $NaHCO_3$ (30 min) provided the highest germination percentage in the CIM-Megha (85.0%) and Wild genotype (76.3%).

Paritala *et al.* (2017) studied the effect of different PGRs on shooting response from root decapitated embryonic axes.They obtained the highest growth response accounting 91.1 percent in BAP 1.0+NAA 0.5, however, a percentage shooting response of 73.3 per cent, and an average number of shoots/explants of 12.3 per cent were obtained in BAP 1.5. Multiple shoot induction from cotyledons was maximum in BAP 2.0 (95.6), BAP 3.0 (95.6) and 2-iP 2.0+NAA 1.0(95.6).

Suhaini *et al.* (2020) investigated the characterization of andrographolide in *A. paniculata* under various cultivationconditions and observed that plant height was highest for T_1 and T_3

(32.51cm). Treatment T_5 has the greatest number of branches (23.40/ plant), whereas treatment T_6 has the least branches (17 / plant). T_3 resulted in a considerable higherleaf count/plant (141). Treatments T_1 and T_2 showed the highest dry weight of 2.4 g. Treatment T_3 had the maximum andrographolide content (0.7g/ml) whereas T_5 had the lowest (0.67g/ml).

Pal *et al.* (2019) investigated the effects of planting date and plant geometry on the growth and yield characteristics of Kalmegh cv. Megha, CIM. The seedling planting on June 15th was better in all growth and yield parameters. Planting spacing of 30x20 cm produced the best result for plant height (68.75cm), plant girth (7.75 mm), number of secondary branches (20.35), number of leaves/plant (78.84), plant dry weight (19.26gm), and total dry matter yield (27.38q/ha).

Chandana *et al.* (2018) studiedinteraction betweenorganic treatmentsand spacingongrowth parametersof *A. paniculata* and found a significant effect. Among all the interactions, maximum growth parameters were recorded in thetreatment M_1S_3 – FYM (30 t/ha) + Arka microbial consortium (AMC) with spacing S_3 (30 x 45 cm), followed by M_3S_3 – Neem cake (7.5 t/ha) + Arka microbial consortium (7.5 l/ha) with spacing S_3 (30 x 45 cm). Minimum growth was recorded in the treatment M_5S_1 Control with spacing S_1-15x15 cm.

Semwal *et al.* (2010) explored the role of planting geometries and weed control practises on the growth and herbageyield of Kalmegh. They found planting geometries, plant height was maximum at 30× 20 cm spacing, however greaternumber of branches, plant spread/plant and LAI observed at P_3 (50× 30 cm), during both the years. Higher dry matteraccumulationbycrop/m^2 and dry herbage yield (q/ha) was maximum in P_1 (30×20cm) in both of the years.

Kumari *et al.* (2018) examined the effect of growth regulators on Kalmegh yield and alkaloid content. In one cropping season, the application of 150 ppm paclobutrazol resulted in the highest stem andrographolide content (1.051) and total andrographolide yield (49.23 kg/ha). Foliar application of NAA at 50 ppm was immensely effective, resulting in maximum cumulative dry herb yield, drying percentage and total andrographolide production (3662kg/ha, 54.5 % and 58.89 kg/ha, respectively).

Tiwari *et al.* (2012) examined the effect of nitrogen sources and amounts on Kalmegh growth, yield, and quality. Among organic nitrogen sources, farmyard manure generated the highest growth, fresh and dry herbage yield (34.03and 23.74 q/ha), andrographolide content (2.37 %), and yield (80.40 kg/ha) with the highest net income (Rs. 1.12 lakhs/ha).The highest BC ratio was found in poultry manure treatment (4.78).

Verma *et al.* (2018) investigated the effects of integrated nutrient management on the growth characteristics of Kalmegh. The results showed that higher growth attributes were recorded in the plots treated with vermicompost @5t/ha, whereas among different Nitrogen doses, an increasing growth trend of Kalmegh was observed in the plots treated with 75 (37.5+37.5) kg N/ha divided into 2 splits (first as basal and second as supplemental as top dress at 25 DAT) and 75 kg N as basal.

Himbindu *et al.* (2017) explored the role of planting and harvesting times on Kalmegh

growth, herbage yield and andrographolide content. The crop planted on August 1st had the highest growth. The crop harvested at the blooming stage had the highest number of leaves per plant (301.67) and andrographolide content (2.55%).

Ashok *et al.* (2002) assessed the effects of ageing on andrographolide content in *A. paniculata*. The ideal harvestingperiod was found to be 120 days after sowing to obtain higher biomass with the highest andrographolide content.

Detpiratmongkol *et al.* (2017) evaluated the performanceofvariouslocal Kalmegh cultivars at various plantingdates. According to the findings, the best Prachinburi local cultivar had the maximum plant growth and dry matteroutput. Planting dates had a substantial influence on growth and yield, which dropped with earlier planting dates and increased with later planting dates, with the maximum alues attained when cultivated 1stJune.

Meena *et al.* (2017) evaluated the economics of Kalmegh management utilizing various weed control techniques. Incomparison to the weedy check treatment, all treatments considerably boosted fresh and dried herbage yield. The weed-free treatment had the highest fresh and dry herbage yields (25.070 and 4.693t/ha, respectively) (T_{10}). Weed free had the highest gross returns, netreturns, and B:C ratios (T_{10}) (15.20).

Conclusion

Considering the plant's useful benefits, there is a tremendous opportunity and need to cultivate Kalmegh as acommercial crop on a large scale by employing efficient production technology to increase yield, productivity, andquality traits without jeopardizing the natural resource base as indiscriminately from natural sources, resulting in a dramatic drop in the herb's availability to the industry. Following conclusion for good production practices can be drawn from the presented seminar. *A. paniculata* seeds are treated with 200 ppm GA_3 and hot water for 30 minutes, the germination rate is greatest. GA_3, BAP 1.5 (mg/l), and BAP1.0+NAA0.5 (mg/l) were the best performing PGRs for *in vitro* regeneration. *A. paniculata* planted in the open with cocopeat and compact medium yields a superior nursery plant. Planting between June 1st and June 15th and harvesting after 90-120 days at the flowering stage results in the highest production and increased and rographolide concentration. A planting spacing of 30 x 20 cm or 30 x 45 cm, alongwith FYM, Vermicompost and poultry manure at 75: 50: 50 kg NPK/ha, is indicated for optimal herbage output.Irrigation support contributed to better yield. Seed treatment with NAA 50 ppm and paclobutrazol 150 ppm can further assist in obtaining good dry herb and andrographolide yield.

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Seminar No. 16

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AGROFORESTRY SYSTEMS FOR SALT AFFECTED REGIONS

Introduction

Soil salinity affects plant growth due to the osmotic effects of salt, poor soil physicochemical properties, nutrition imbalances, and ion toxicities in most of the arid and semi-arid regions. Conventional cultivation of arable crops with saline irrigation has not been

sustainable. Concerted research efforts have shown that by applying appropriate planting and other management techniques like sub-surface planting and furrow irrigation and screening of plants for salt tolerance, the degraded lands can be put to alternative land use system (agroforestry) by integrating salt-tolerant forest and fruit trees, forage grasses, medicinal and aromatic, and other high value crops.

Review of literature

Dagar *et al.* (2016) changed the geometry of Eucalyptus plantation in waterlogged saline soils in North-West India for higher wood biomass, carbon sequestration and water table draw down and thereby improving crop productivity.

Banyal*et al.* (2017) recommended saline irrigation in cyclic mode for good establishment ofEucalyptus and Melia trees for saline ecologies.

Singh *et al.* (1995) successfully intercropped rice–wheat/rice–*Berseem* with poplar,*Eucalyptus* and *Acacia* trees in moderate alkali soil in North-West India.

Wickie *et al.* (2013) explored GHG balance and economic performance of agroforestry systems in saline regions of India, Bangladesh and Pakistan and found out that bio-saline agroforestry is economically viable in South Asia under different settings - type and severity of salt-affectedness and markets for wood products.

Tomar *et al.* (2004) recommended augar hole method of planting for fruit trees in alkali soil for better establishment and growth performance.

Dagar *et al.* (2001) successfully grewPomegranate and Salvadora on raised bunds to avoid water stagnation and rice–wheat and berseem– kallar grass rotation on sunken-beds on highly alkali soil (pH > 10).

Dagar *et al.* (2008) established *Ziziphus mauritiana, Carissa carandas, Feronia limonia, Emblica officinalis,* and *Aegle marmelos* plantation by irrigating with saline water up to EC 10 dS/m and found Karonda–barley as a sustainable system with limited saline irrigation for dry region.

Dagar *et al.* (2015) recommended alternate irrigations of low and high salinity for improved performance of all components in fruit-based agroforestry systems in semi-arid hyperthermic camborthids soils of north-west India.

Singh (1995) found out that *Leptochloa* grass planted in the interspaces of *Prosopis juliflora* improved the soil to such an extent that less tolerant but more palatable fodder species such as Persian clover, Egyptian clover, Lucerne and Sweet clover could be grown under mesquite trees after 50 months.

Singh *et al.* (2014) also bio-ameliorated alkali soils by intercropping *Leptochloa* grass in *Prosopis juliflora* for four continuous years and replaced it with more palatable *T. alexandrinum* for next six years.

Kaur *et al.* (2001) estimated the amount of total carbon input through net primary production as 2.81 t/ha/yr in *A. nilotica x D. bipinnata*, 5.37 t/ha/yr in *D. sisoo x D. bipinnata* and 6.50 t/ha/yr in *P. juliflora x D. bipinnata*.

Kaur *et al.* (2002) also observed a significant relationship between microbial biomass carbon and plant biomass carbon (r = 0.92) as well as the flux of carbon in net primary productivity (r = 0.92) in the same site

Rao and Gill (1990) found out thatorganic fertilization was 2.5 times as effective as inorganic N fertilization by continuously growing *Sesbania* for 4 years in alkali soil. This improved the yield of succeeding rice and wheat crop.

CSSRI (2013) successfully conducted experiments on aqua-forestry in saline and waterloggedparts of southwestern Haryana and Punjabwith B: C ratio of 4.45.

Gajender *et al. (*2016) promoted multi-enterprise agriculture for sustaining livelihood security of small farmers in salt affected areas of Indo-Gangetic plains

Conclusion

Agroforestry systems in salt affected regions will not only benefit an individual farmer but the entire community in the area. In salt affected areas, agroforestry will help in decreasing pH and electrical conductivity and improve the organic matter and fertility status of the soil, thereby making them more productive. By adopting management practices like changing the geometry of planting tree crops, site specific planting techniques, optimum utilization of saline water irrigation in cyclic mode and planting compatible tree components will help in improving the livelihood of farmers in degraded lands.

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Seminar No. 17

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Degree: Ph.D. Forestry (Silviculture &Agroforestry)	**Course No**: FOR 692
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FRUIT BASED AGROFORESTRY SYSTEMS IN DRYLANDS

Introduction

Crop production on drylands in particular results in low, unstable and often uneconomic yields because of aberrant monsoon behavior. These marginal lands are not able to sustain arable crops particularly during the drought conditions. Tree component in dryland agriculture increases production and income, besides imparting stability to the farming system. Among the alternate land use system developed, fruit based agroforestry systems are readily picked up by the fruit growers due to cash benefits derived from these system. The fruit based agroforestry system can be defined as a planting system comprising combinations of plants with various morpho-phenological features to maximize the natural resource use efficiency and enhanced total factor productivity. Fruit based cropping system is now considered to be the most ideal strategy to provide food, nutrition and income security to the people (Chundawat, 1993). Integration of annual crops with fruit trees yields multiple outputs that ensure production and income

generation in a sustainable manner (Randhawa, 1990). The main components of fruit based agroforestry systems are main crop, filler crop and inter crop. There are different kinds of fruit based systems using across the country *viz,* mango, guava, ber, aonla, sapota etc. Several researchers reported that fruit based agroforestry systems were useful for improving economic returns of the farmers, generating employment, higher production, soil fertility status and quality characters of fruits under drylands.

Review of Research work

Growth, Yield, Quality, Soil fertility status and Economics

Mango

Swain (2014) conducted an experiment to assess the effect of various intercrops on the performance of mango in the rainfed uplands of Odisha. The results of the study revealed that the mango + guava +cowpea intercropping system exhibited better performance which has been reflected in the form of plant height, fruit weight and fruit yield of mango closely followed by mango + guava + french bean system.

Rathore *et al.* (2013) conducted an experiment on performance of mango based agri-horticultural models under rainfed situation of western Himalaya in two phases. In the first phase, mango + cowpea + toria system, in the second phase mango + turmeric system significantly improved the fruit quality and soil properties as compared to initial values.

Sharma *et al.* (2017) studied mango based agroforestry system under rainfed condition of west bengal. The fruit yield of mango tree was recorded highest (6.68 and 9.51 t ha^{-1}) under mango + gamhar + groundnut during 2015 and 2016, respectively, followed by mango + gamhar + maize and mango + gamhar (without intercrops) during both years. The lowest fruit yield was observed (4.06 and 6.23 t ha^{-1}) under sole mango plantation.

Ber

Saroj *et al.* (2003) studied ber fruit yield under ber based agri – horti system. They recorded significantly higher fruit yield in 6x6 m spacing (14.44 q/ha) followed by 16x4 m and 8x8 m spacing. Further, Indian aloe recorded higher fruit yield (13.55 q/ha) followed by cluster bean – mustard (9.80 q/ha) and ground nut- wheat (9.62 q/ha) crop rotation.

Solanki and Ramnewaj (1999) studied the performance of *Zyziphus* based agri-horticultural systems on yield of *Zyziphus* at AICRPDA, dantiwada. They reported that the yield and gross income of ber was more under *Ziziphus* + mung bean and Z*iziphus* + sorghum systems

Aonla

Das *et al.* (2011) studied the effect of different intercrops on aonla based agri-horticultural systems. Among different treatments, the treatment aonla + turmeric significantly increased the growth, fruit characters of aonla and soil properties.

Awasthi *et al.* (2009) performed an experiment on intercropping with aonla. Growth parameters in terms of plant height, stem girth and canopy spread of aonla was recorded to be significantly increased with intercrops compared with its sole plantation. Further, higher grain yield (*Kharif*) was recorded in mothbean–chickpea (497 kg/ha) and mothbean-fenugreek (465 kg/ha) crop sequence. Amongst the winter (*rabi*) crops, grain yield of fenugreek, chickpea,

mustard and cumin were higher by 28.05, 38.11, 19.96 and 36.50%, respectively, when grown in association with aonla compared to its sole crops.

Singh *et al.* (2020) investigate different combinations of cucurbitaceous crops with aonla based agroforestry system under rainfed semi arid condition. They discovered that the highest yielding combination was aonla + bottle gourd (140.48 q/ha), followed by aonla + pumpkin (132.75 q/ha), aonla + cucumber (121.46 q/ha), and aonla + bitter gourd (105.17 q/ha), with the lowest cumulative yield being aonla + sponge gourd (103.23 q/ha).

Tamarind

Mutanal *et al.* (2007) conducted an experiment to assess the mixed cropping of trees with tamarind at forest research station, prabhunagar (dharwad) during 1985. At the end of 20th year of experimentation it was found that tamarind growth (ht and dbh) was higher with *C. equisetifolia* (10.46 m and 20.85 cm respectively) and *E. tereticornis* (10.63 m and 19.32 cm respectively) as compared to other tree species. Among tree species, height and dbh were higher in *C. equisetifolia* (21.60 m and 23.70 cm respectively) and *E. tereticornis* (18.34 m and 18.21 cm respectively) as compared to *D. sissoo* (8.46 m and 11.36 cm respectively).

Kumar *et al.* (2010) observed performance of safed musli in tamarind plantation as intercrop and as sole crop in open area. They found higher growth attribute, yield attribute of safed musli and B: C ratio under tamarind plantation as compare to open area.

Khan *et al.* (2010) studied economics of tamarind based agri-silvi-horti system. They recorded maximum and minimum net returns in tamarind + custard apple + red gram (Rs 29,972) and tamarind + curry leaf + cow pea (Rs 12,866), respectively.

Pomegranate

Soni *et al.* (2020) observed that different intercrops showed positive effect on height, girth and canopy spread of pomegranate over sole plantation.

Combination of different fruit tree

Dayal *et al.* (2015) investigate the performance of 3 legume (cluster bean , cowpea and mothbean) under different fruit trees. They reported that all 3 legume performed better under ber compare to aonla and pomegranate.

Meena *et al.* (2017) reported that the cropping sequence fenugreek- okra inter cropped with ber exhibited highest net return (Rs. 8,09,215 ha^{-1}) and BCR (4.68) followed by intercropping of ajwain- tinda cropping sequence with ber which resulted a net return of Rs.7,22,075 ha^{-1}. Thus, it is inferred that intercropping of fenugreek- okra cropping sequence with ber is recommended for realizing higher system productivity, net returns and BCR.

Arya *et al.* (2011) observed that the maximum benefit: cost ratio of 3.48:1 when crops were grown under combination of aonla + ber + karonda + moth bean + mustard. They also noticed higher benefit: cost ratio of 2.22:1 for ber alone among the perennial components.

Conclusion

Mounting pressure on our natural resources due to rocketing population rise has ushered in large scale degradation of our environment and ecosystem thus calling for immediate attention for seeking newer approaches in cropping system to meet the food, fibre, fire wood and timber

requirement of the 21st century. For sustainable management of dry lands and for enhancing the economic viability of the cropping system, partial shift from the existing high input requiring rotation to low input requiring system is the need of time. Several researchers reported that fruit based agroforestry systems were useful for improving economic returns of the farmers, generating employment, higher production, soil fertility status and quality characters of fruits under drylands.

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Seminar No. 18

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SEASONAL VARIATION IN TREE LEAVES NUTRITIONAL COMPOSITION

Introduction

Nutrition is important for all organisms. However, in food-producing animals, it is especially important due to the nature of the production systems (e.g., confinement), the economics of production or the products (e.g., meat, eggs, milk) generated. Fodder trees in general, have higher biomass than grasses and enough protein to support growth and milk production, especially in the dry season when these species grow extra foliage. The tree foliage is an important source of protein supplement for ruminants fed low protein forages. Tree foliages have good proportions of nutrients that keep intestinal micro-fauna active for digesting cellulosic biomasses (Singh and Todaria, 2012; Singh *et al.*, 2015). They can also help to bridge the wider gap between demand and supply of nutrients in feeding. The nutritional analysis includes proximate composition, minerals, cell wall composition and phytochemicals.

The proximate analysis revealed the presence of ash, moisture, protein, fiber, fats and carbohydrate (Haddi *et al.* 2009, Rodríguez *et al.* 2002, Mchargue and Roy, 1932, Tsugiyuki 1997, Gemede and Ratta, 2014, Das, 2019). The nutrient composition of plants is influenced by many environmental and physiological factors, such as season, elevation, soil, site, climate, and stage of tissue maturation. Perhaps the most significant variations are associated with tissue maturation and season (Blair and Epps, 1969). Therefore, it is important to study such variations so that tree foliage can be harvested in season when particular species possess most of the nutrients and less anti-nutritional factors.

A brief review of research work:

Azim *et al.* (2001) studied the seasonal proximate composition and cell wall constituents of various fodder tree leaves. They concluded that maximum dry matter (DM) (65.60%) and hemicelluloses (16.50%) were recorded for *Elaeagnus pungens* L. Maximum crude protein (CP) (27.20%) was recorded during spring from *Ailanthus excelsa* Roxb. Maximum neutral detergent fiber (NDF) (44.20%), acid detergent fiber (ADF) (27.50%) and acid detergent lignin (ADL) (8.80) from *Robinia pseudoacacia* L. during the winter season. Maximum ash (14.50%) recorded from *Morus alba* L. during spring.

Bakshi and Wadhwa, (2004) worked on the seasonal variation in the chemical composition of leaves (%) of twelve forest tree species of the semi-hilly arid region and reported that Ether extract (EE) (3.24%) and ADL (15.33%) during the hot humid season. OM (92.24%), CP (14.35%) and NDF (57.66%) were recorded highest during fall and ADF (44.06%), Cellulose (23.48%) and Hemicellulose (16.86%) during winter.

Kant *et al*. (2017) investigated monthly variations in the nutritional value of *Leucaena leucocephala* leaves and found maximum DM (33.20), CP (23.22), NEF (52.59), phosphorus (P) (0.30) total tannin (2.77) and mimosine (3.80) in August while, EE (6.04), CF (18.44), NDF (39.37), ADF (23.11), Total ash (8.23), acid insoluble ash (AIA) (1.42) and calcium (Ca) (1.18) in January.

Katoch *et al.* (2017) studied seasonal variation in NDF (%) of *Bauhinia variegata* (67.00±1.88), *Grewia oppositifolia* (62.60±1.69), *Albizzia lebbek* (65.00±1.87), *Celtis australis* (66.00±1.12), *Bambusa arundinacea* (70.20±3.56), *Morus alba* (59.80±4.74), *Arrtocarpus lakoocha* (63.80±2.23) and *Albizzia chinensis* (69.60±3.16) recorded maximum in January.

Moleele (1998) worked on cattle diet composition for different seasons and recorded maximum CP (18.01) and K (1.28) in March and Ca (2.11) in September from *Dicrostachys cinerea.* Maximum P (0.094) and Mg (0.46) were observed during September in *Acacia nigrescens* and *Grewia flava*, respectively.

Niinemets and Tamm (2005) studied time-dependent variations in nitrogen (N), P and potassium (K) contents of attached and freshly fallen leaves of *Populus tremula* and *Tilia cordata* in deciduous temperate forest stands and observed decreased N, P and K content (%) as days of year increases.

Yan *et al.* (2016) analysed nutrient concentrations in mature and senesced leaves of the tree species from northeast China. They reported that N, P, K, Mg, Cu and Zn were higher for

mature leaves in all the selected species while Ca was higher in senesced leaves for all the species.

Dimitrios and Moustakas (2018) examined seasonal changes in nutrients concentration in Olive (*Olea europaea*) leaves. They concluded that zinc (Zn), manganese (Mn), boron (B) and iron (Fe) concentration increased during vegetative growth, flowering and fruiting; Zn and Mn recorded maximum during July and B and Fe in June.

Forwood and Owensby (1985) studied tannic acid equivalent percentages of Bur oak (*Quercus macrocarpa*), Cottonwood (*Populus deltoides*), Elm (*Ulmus rubra*), and Osage orange (*Maclura ponifera*) leaves. They found maximum tannic acid equivalent percentages of Bur oak (19.30), Cottonwood (6.60), Elm (6.90) were recorded during early October while for Osage orange (5.70) during late October.

Navale *et al.* (2017) worked on seasonal variation in anti-nutrient content and mineral content of *Pittosporum floribundum.* The P (0.24%), K (2.55%), Mn (47 ppm) contents were higher during the spring season. The winter season exhibited the highest Ca (4.38%), Cu (21.80 ppm), Fe (696.20 ppm) and Zn (54.40 ppm) contents. Anti-nutritional seasonal variation in phenolic compounds and antioxidant activity in leaves of *Cyclocarya paliurus*. A significant seasonal variation of phenolic compounds was observed in the leaves and the highest content appeared in May, July, and November.

Forwood and Owensby (1985) experimented with *in-vitro* dry matter digestibility (%) and concluded that maximum IVDMD of Bur oak (46.50 & 39.30), Cottonwood (63.00), Elm (53.80), and Osage orange (75.50) leaves harvested from trees during the month of early October.

Palo *et al*. (1985) studied the seasonal change in ruminant *in vitro* digestibility of fine Birch (*Betula papyrifera*) twigs and concluded that the highest % *in vitro* dry matter digestibility was recorded in June.

Azim *et al.* (2001) checked the *in vitro* dry matter digestibility (%) of various fodder tree leaves at 48 h after incubation. They revealed that *in vitro* DMD was higher ($p<0.05$) in Ailanthus and Poplar in spring while it was higher ($p<0.05$) in Elaeagnus, Mulberry and Robinia in winter. There was no ($p<0.05$) seasonal effect on in situ DMD of Salix.

Bakshi and Wadhwa (2004) studied the effect of season on the degradation of CP of forest tree leaves of the semi-hilly arid region. The rapidly soluble fraction (a) of CP was significantly higher during the winter season. A reverse trend was observed in the case of potentially degradable fraction (b). 48 h and effective degradability (Ed) of CP were significantly higher during the fall season.

Conclusion

The plants studied differed in their proximate composition, minerals, cell wall composition and phytochemicals between species and between times. The high variability in the tree leaves suggests that the species-specific strategies can be more important to characterize the chemical plant quality as food than the presumed responses depending on the current general theories. In spring, leaves and twigs are most succulent, and their dry-matter fraction observed

highest in protein, ash, and phosphorus, and lowest in crude fiber. By mid-summer, contents of moisture, protein, ash, and phosphorus decline appreciably, while crude-fiber content increases. The superior nutrient quality of leaves emphasizes the importance of broad-leaved evergreens. Farmers can utilize *Acacia/Vachelia* spp., *Morus alba*, *Grewia* spp., *Salix* spp., *Populas* spp., *Ziziphus* spp., *Leucaena leucocephala*, etc. as an important fodder species for summer and winter season to feed the cattle. All these sources of variability create a diverse and changing chemical landscape in which herbivores have to select their diet, not only between species but also between different times and sites for the same species as well.

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