Proceedings of the

NAU-IES-IUFRO Conference

Tree Based Diversified Land-use System

Augmenting Livelihood Security and Industrial Growth

(February 15-17, 2023)

Organizers

Sponsored by

NAVSARI AGRICULTURAL UNIVERSITY

Commencing with a college of agriculture in 1965, erstwhile Gujarat Agricultural University, Navsari Agricultural University (NAU) came into existence with the promulgation of Gujarat Agricultural University Act 2004 on May 1, 2004. Its jurisdiction covers seven districts of South Gujarat viz., Surat, Navsari, Bharuch, Valsad, Narmada, Tapi and Dangs. At present, there are eight Colleges imparting seven bachelors, twenty-seven Master's and twenty-one doctoral degree programmes. In the faculty of Agriculture, Horticulture, Forestry, Agribusiness Management, Agricultural Engineering and Agricultural Biotechnology. Further, there are 25 research centres at 15 locations to carry out need based research on mandate crops *viz.,* paddy, sugarcane, cotton, sorghum, small millets, mango, banana, sapota and vegetables. The NAU, extensively reach to the farmers and cover sprawling south Gujarat through its 5 KVKs located at Navsari, Surat, Waghai, Vyara and Dediyapada and Sardar Smruti Kendra, T & V and ATIC at Navsari to undertake dissemination of newer technologies to end users of seven districts of South Gujarat. [www.https://nau.in]

INDIAN ECOLOGICALSOCIETY

The Indian Ecological Society (IES) was established in 1974. In the 1960s and 1970s, the main emphasis was on increasing production, which led to the 'Green Revolution'; however, its impacts on ecology, natural resource, environment were not the prime issues. The IES was formed at Punjab Agricultural University to address these issues. IES is one of the pioneering organizations of India engaged in advances in ecological sciences and environmental protection to encourage and promote ecological studies in the country and to integrate research in different fields of ecology. The objectives were modified from time to time keeping in mind the priority areas in the field of ecology and environment. The Society attempts to fulfil the above objectives by publishing the Indian Journal of Ecology since 1974 and organizing scientific events. The Society is managed by senior academia and assisted voluntarily by a multidisciplinary team of scientists. [www.https://indianecologicalsociety.com]

THE IUFRO, VIENNA, AUSTRIA

International Union for Forest Research Organizations (IUFRO) is a non-profit, non-governmental international network of forest scientists, which promotes global cooperation in forest-related research and enhances the understanding of the ecological, economic and social aspects of forests and trees. IUFRO is the global network for forest science cooperation. The network is open to all individuals and organizations dedicated to forest and forest products research and related disciplines. It unites more than 15,000 scientists in about 650 Member Organizations in over 125 countries, and is a member of the International Science Council. Scientists cooperate in the IUFRO on a voluntary basis to contribute to achieving the Sustainable Development Goals set by the United Nations. [www.https://iufro.org]

Proceedings of the NAU-IES-IUFRO Conference

on

Tree Based Diversified Land-use System:

Augmenting Livelihood Security and Industrial Growth

(February 15-17, 2023)

Organized by

Navsari Agricultural University (NAU), Navsari, Gujarat, INDIA
&
Indian Ecological Society

(PAU, Ludhiana, Punjab) Gujarat Chapter

In association with

International Union for Forest Research Organization, Vienna (Austria)

with financial support

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सत्यमेव जयते

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सचिव (डेयर) एवं महानिदेशक (आईसीएआर)
Secretary (DARE) &
Director General (ICAR)

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली–110 001

GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION (DARE)
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MESSAGE

It gives me immense pleasure to learn that College of Forestry, Navsari Agricultural University, Navsari, Gujarat in association with the Indian Ecological Society, Ludhiana Punjab, India and International Union for Forest Research Organizations (IUFRO), Vienna are organizing an International **Conference** on "**Tree Based Diversified Land-use System: Augmenting Livelihood Security and Industrial Growth**" during February 15-17, 2023 at at NAU, Navsari, Gujarat. The three-day conference is an unique opportunity for the deliberations on recent and emerging trends and technologies on different aspects of farm to factory linkages, initiatives and successes, fast growing tree for lives and livelihood, forest dweller's and farmer's requirement and the new ideas towards utilization and value addition of NTFPs for livelihood security, etc. The knowledge about forest certification and ecosystem services among scientific forum, potential to create new jobs among youths and reduce distress migration to urban cities along with trees - improvement, silviculture and management, climate change and natural resource conservation, forest economics and policy shall also be shared and discussed in the conference. The Conference will provide information and explore all possible opportunities and potential areas in sustainable utilization of forest resources, their conservation and entrepreneurship avenues.

I am confident that the conference would provide a platform for discussion and deliberations on technological interventions related to the various themes of forestry sector and usher into very concrete actionable recommendations. The initiative taken by the Team-NAU in organizing this Conference deserves appreciation.

I wish the Conference a grand success.

(Himanshu Pathak)

9th February, 2023
New Delhi

Navsari Agricultural University
Navsari, Gujarat

Dr. Z. P. Patel
Vice Chancellor

Message

With an extreme pride and gratification, I am writing this message for the conference on "*Tree Based Diversified Land-use System: Augmenting Livelihood Security and Industrial Growth*" to be held at Navsari agricultural University, Navsari, Gujarat, India in association with the "Indian Ecological Society", Ludhiana Punjab, India and International Union for Forest Research Organizations (IUFRO), Vienna, from 15-17 February, 2023. The conference is organized with the financial support from the Indian Council of Agricultural Research (ICAR) and the Science & Engineering Research Board (SERB).

Forests and tree-based land use systems are of utmost importance in conservation of natural resources and catering the demand of increasing human and livestock population. Particularly the diversified tree-based farming systems, where timber/fruit/fuel/fodder and other product yielding woody components are integrated to fulfil the nutritional and health requirements of rural people and industry, is being advocated as an economically and ecologically viable systems in the present changing scenario. Forests not only provide above said tangible and non-tangible benefits, but harbour huge biodiversity, may it be faunal or floral. In the changing climatic scenario too, scientists and policy makers look back to natural biodiversity for wild races of plant and animal to develop resistant species and varieties. The conference is also aim to bring multidisciplinary stakeholders throughout the country to share their knowledge on focused themes.

I wholeheartedly congratulate the energetic team of organizers and faculty members of College of Forestry, NAU for taking up the task of organizing this conference. I am confident that the deliberations would be of great use in understanding the latest research findings, domestications of improved varieties and adaptation of improved practices meaningfully for enhancing livelihood and environmental security as well as industrial need through this event.

I convey my heartiest greetings to the organizers on the occasion and wish the programme a grand success.

(Z. P. Patel)

Navsari

February 07, 2023

VCSG Uttarakhand University of Horticulture & Forestry
Ranichauri, Tehri Garhwal-249199, Uttarakhand, INDIA
(A State Agriculture University of Government of Uttarakhand, India)

Dr. Parvinder Kaushal
Vice Chancellor

Message

It is indeed a matter of great pleasure to know that the Navsari Agricultural University (NAU), Navsari, Gujarat and Indian Ecological Society (IES-PAU, Ludhiana, Punjab) in association with International Union for Forest Research Organization (IUFRO), Vienna (Austria) organizing a thee days Conference on "Tree Based Diversified Land-use System: Augmenting Livelihood Security and Industrial Growth" during February 15-17, 2023 at Navsari Gujarat, India.

Trees are integral part of traditional and modern land-use system for accompanying Livelihood Security and Industrial Growth. Agroforestry and farm forestry are such tree-based landscape and considered as need of the hour for maintaining diversity and meeting the demand of food and wood. Tree based Land-use system closely linked with integration of agriculture, forestry, and livestock along-with environmental services. It is also considered as a sustainable way of life for the rural communities by providing food, livelihood security and reduces vulnerability. In order to have better tree base support system the different areas viz forest genetic resources, short rotation forestry, biotechnological interventions in forestry, clonal tree systems, precision silviculture and other similar interventions are important for enhancing tree productivity, livelihood support and sustainability.

I am sure, that the present conference on Tree Based Diversified Land-use System organized by NAU, IES-PAU in association with IUFRO will definitely help in refining the research priorities with inputs from professionals, stakeholders, scientists of various institutions, academicians, policy makers, state officials and tree growers in augmenting Livelihood Security and Industrial Growth. I wish the conference a grand success.

(Parvinder Kaushal)
Vice Chancellor

Dated the 8th February, 2023

Prof. Rajeshwar Singh Chandel
Vice Chancellor

Dr. Y S Parmar University of Horticulture and Forestry

Ref. No. 766 Date 06.02.23

Message

I am immensely pleased to know that Navsari Agricultural University, Navsari, Gujarat and the Gujarat chapter of Indian Ecological Society is going to organize a conference on 'Tree based Diversified Land Use System: Augmenting Livelihood Security and Industrial Growth' in association with IUFRO from 15-17th February, 2023.

I congratulate the organizers for choosing such a topic of utmost importance which addresses the tree based land use systems to meet out the triple objectives of Industrial growth, ensuring ample livelihood avenues for the local population while meeting the challenges posed by global climate change.

The various themes like Farmers, Foresters and Fabricators; Value addition of Forest Genetic Resources, Silviculture and Agroforestry; Forest Climate Change; Natural Resource Management; Forest Economics and Policy are well thought of and linked to scientific fraternity, farmers, industry and other stakeholders. I am confident that deliberations during the conference will come out with new ideas, which will be of immense value to the scientific community and will go a long way in the dissemination of latest advancements among the various beneficiaries.

I am hopeful that the conference will provide an excellent platform for holding discussions and fostering inter-disciplinary cooperation for sustainable development. The multi-disciplinary flow of information will promote applied research and maximize the industrial connectivity for mutual benefits.

I extend my best wishes for the grand success of the conference and publication of souvenir on this occasion.

Prof Rajeshwar Singh Chandel

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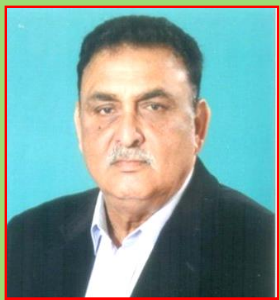

Dr A K Dhawan
President
Indian Ecological Society

THE INDIAN ECOLOGICAL SOCIETY
PUNJAB AGRICULTURAL UNIVERSITY
LUDHIANA-141 004, INDIA

Message

The 'Indian Ecological Society' established in 1974, is one of the pioneering organizations of India, engaged in advances in ecological sciences and environmental protection through various activities at national and international levels, inviting expert inputs, knowledge sharing, deliberations, identification of SDGs and required action plans thereof for sustainable development of agriculture and allied sciences. The Society attempts to fulfil the above objectives by publishing the 'Indian Journal of Ecology' (since 1974), proceedings and such other publications as may be considered desirable. The journal is considered a premier journal reporting research findings in the field of basic and applied ecology.

Forests are major contributors to the Earth's capability to maintain its climate. Forest based land use system provides natural defence against climate change and acts as a sink for carbon dioxide. This assists in purifying the atmosphere and controlling rising temperatures. Deforestation negates these benefits. Society benefits from forests in various ways and due to the multiple functions of the forests. Providing goods and services for the increasing population has become major challenge for our times. Balancing the demand for tree-based products and forest ecosystem services should be managed in sustainable way.

Navsari agricultural University, Navsari, Gujarat, India in association with the "Indian Ecological Society", Ludhiana Punjab, India and International Union for Forest Research Organizations (IUFRO), Vienna, Austria is organizing three days international conference on "*Tree Based Diversified Land-use System: Augmenting Livelihood Security and Industrial Growth*" from 15-17 February, 2023. The Indian Ecological Society (IES) on various occasions in the past has also successfully engaged in diverting brains of the world to think of ways to protect the environment and promote ecological studies. I am sure that, the conference deliberations will focus on finding the resolutions for the existing challenges in forestry sector to show the way for livelihood security of the dependent communities through tree based diversified land-use system. I am confident that, conference will be very much helpful for the synergetic group including students, research scholars, farmers, foresters, fabricators, young scientists, senior scientists, administrators, policy makers and all other concerned stakeholders.

A.K. Dhawan

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Dr. S. K. Chauhan
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Nauni, Solan 173 230, India

Message

It gives me immense pleasure to know that Navsari Agricultural University, Navsari, Gujarat and Indian Ecological Society, Ludhiana in association with International Union of Forest Research Organizations, Vienna (Austria) is organizing a conference on "Tree based Diversified Land use System: Augmenting Livelihood Security and Industrial Growth" (February 15-17, 2023) with six different themes of relevance. I have the honour to be the Co-patron of the organizing committee, representing IUFRO as Deputy Coordinator of Agroforestry Section (1.04.00) and Indian Ecological Society as General Secretary.

The topic indeed is as per the need of the day to address the current issues of constraints being felt to meet the growing demands of the people both for food and the forest based services. As estimated, about 2400 million people are facing fuel wood problems, of this 50 per cent are in Asia. In another estimate, it is reported that to meet the demand for food, fuel/timber and fodder for the growing human/animal population, we require additional land to the tune 8, 40 and 10 million hectares, respectively. This is neither practical and nor possible without the diversification in landuse from traditional cultivation practices. Mixing of different trees and crops is actually more befitting for developing countries. The agronomy of both, that is trees and the associated crop needs to be developed in an integrated way so as to improve the input and output balance and make the system more sustainable and environment friendly.

I understand that a large number of scientists from various organizations including State Agricultural Universities, ICAR/ICFRE Institutes, Officials of line departments, Industry, NGOs, farmers and students are participating in the conference to address their pressing concerns. The conference has liberally been supported by the funding agencies. I am confident that the deliberations will be highly useful in improving the on-farm productivity, surrounding environment and moderate the changing global climatic scenario.

I am sure this conference will be informative, enjoyable and memorable. I convey my best wishes to the organizers for the success of the conference.

Nauni, Solan (HP)
Dated: February 10, 2023

S. K. Chauhan
Deputy Coordinator, Agroforestry
(IUFRO 1.04.00)

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NAVSARI AGRICULTURAL UNIVERSITY

MESSAGE

Forests have been playing many roles since ages by providing shelter, renewable raw materials and energy, timber and non-timber forest products. Apart from direct benefits, forest ecosystem support biodiversity, helps in carbon sequestration and climate moderation. Tree based diversified land-use systems are essential for satisfying the livelihood of the increasing population as well as for fulfil the industrial requirement in sustainable way. Moreover, the secondary agriculture in context to forestry provides value addition to forest products, creating facilities for primary processing and adds value to the basic forest commodities, to allow tribes/forest fringe villagers to get better returns from their harvest. Instances of secondary agriculture are vitamins from minor fruits, essential oil from aromatic plants, bio-fuel from TBOs and ligno-cellulosic biomass, fiber board from MPTs, in addition to medicinal plants and herbal products not yet fully capitalized in India. Therefore, keeping these points in view the Navsari Agricultural University, Navsari, Gujarat & Indian Ecological Society (PAU, Ludhiana, Punjab) Gujarat Chapter in association with International Union for Forest Research Organization (IUFRO), Vienna (Austria) is organizing three days NAU-IES-IUFRO Conference-2023 on “Tree Based Diversified Land-use System: Augmenting Livelihood Security and Industrial Growth” during February 15-17, 2023 at NAU, Navsari to bird view the challenges of Farmers, Foresters and Fabricators; Agroforestry - A Landscape with Trees for Lives and Livelihood; Tree Improvement, Silviculture and Management; Utilization and Value Addition of Forest Genetic Resources; Forests, Climate Change and Natural Resource Conservation and Forest Economics and Policy.

I am sure that this Book of Abstracts & Souvenir on “Tree Based Diversified Land-use System: Augmenting Livelihood Security and Industrial Growth” will meet the needs of the hour for academicians, researchers, foresters, entrepreneurs, students and progressive farmers.

The rich experiences shared by eminent lead speakers, faculties and students during the NAU-IES-IUFRO Conference-2023 will be very much useful to the participants. I convey my best wishes to the organizers.

Date: 13-02-2023
Navsari

(T. R. Ahlawat)

From the Desk of Conference Secretariat

Dr. P.K. Shrivastava

Dr. R.P. Gunaga

Dr. N.S. Thakur

Dr. H.T. Hegde

Dr. M.B. Tandel

Dr. M.S. Sankanur

Forests are very important natural resource helping in ecological balance. Sustainable use of forest resources is critical for better livelihood options and contribute substantially to the economic development of any nation by providing goods and services to the human society, wild and domestic animal and industry. Tree based diversified land use system is very much essential to reduce the vulnerability of people to climate change by providing food and other ecosystem services during critical periods of climate change driven food shortages. In the present scenario, it is required to provide security for food, environment, livelihood and raw material for present and future generation. To address these all, tree based diversified land-use systems are much advocated. Many academicians, researcher, industrialists, policy makers throughout the world have started orbiting around these pertinent issues. With this background, it is planned to take up the scientific event entitled "*Tree Based Diversified Land-use System: Augmenting Livelihood Security and Industrial Growth*" at Navsari Agricultural University, Navsari, Gujarat, India by Indian Ecological Society (Ludhiana, Punjab) Gujarat chapter in association with International Union of Forest Research Organizations, Vienna (Austria) to provide a common forum for scientists, foresters, industry technocrats, policy makers and other stakeholders to discuss the status, issues and management of forest, agroforests and other tree based land use system.

With wide publicity, about 280 abstracts from various academic institutions, research organizations, NGOs, wood based private companies across the states have been received. More than 20 renowned scientists/ academicians from different organizations would be deliberating on themes namely 1. Farmers, Foresters and Fabricators 2. Agroforestry - A Landscape with Trees for Lives and Livelihood 3. **Tree Improvement and Ecology** 4. Utilization and Value Addition of Forest Genetic Resources 5. Forests, Climate Change and Natural Resource Conservation 6. **Silviculture, Forest Management, Economics and Policy**. Furthermore, participating farmers in the brain storming session would have direct interface with wood and timber fabricators to address issues related to quality planting material stock production to harvest of tree crops and marketing.

Apart from Navsari Agricultural University, Navsari and Indian Ecological Society, organizations like Indian Council of Agricultural Research, New Delhi, Science and Engineering Research Board, New Delhi, India have provided financial support. We have also received sponsorship from GSFDC, Vadodara, JK Paper Songadh, Gujarat, Atharva Sales, Navsari, GUJCON Eco Green, Surat and Leen Innovations Private limited India have given financial support to organize this event. It expected to have nice deliberations to put forth valuable inputs for sustainable management, utilization and conservation of forest and tree based diversified land-use system for future generation. The outcome and recommendation of the conference will be synthesized in the form of proceedings for further use.

Dr. P.K. Shrivastava
Chairman

Dr. R.P. Gunaga	*Dr. N.S. Thakur*	*Dr. H.T. Hegde*	*Dr. M.B. Tandel*	*Dr. M.S. Sankanur*
Convener	**Organizing Secretaries**		**Co-Organizing Secretaries**	

Content sheet

Part I – Lead Papers

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Part II – Extended Abstracts

1.1/Lead Paper

Tree-Based Land-Use Systems for Nutritional and Livelihood Security

P.K.R. Nair
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Introduction

Trees are among the largest and most widespread organisms on the planet, but the term "tree" is loosely defined. Trees are among the largest and most widespread organisms on the planet. They provide a wealth of ecosystem services for humans and support much of terrestrial biodiversity. Globally, the estimated total of over 3 trillion (3 x 10*12) trees belong to about 73,000 species (Gatti et al. 2022) and constitute more than 25% of all angiosperms and gymnosperms. A tree-dominated Biome or habitat is usually called a forest, and most trees exist in forests. But trees are ubiquitous. The focus of this paper is on trees outside forests, specifically in agroforestry systems.

Agroforestry

Agroforestry, an interface between forestry and agriculture, is a land-management system where trees and crops, and sometimes animals are grown purposefully in interacting combinations for a variety of objectives. Globally, about 1.6 billion ha of land is under some form of such an integrated system, especially in the tropics, where an estimated 1.5 billion farmers practice agroforestry.

Cultivating trees and crops in combination is an ancient practice that is as old as agriculture, i.e., about 10,000 years. With the advent of the Industrial Revolution, most such traditional practices were abandoned or substituted with commercial agriculture and forestry in the industrialized world, with increasing dependence on the use of chemicals and heavy machinery. The Green Revolution,whichpaved the way for substantial increases in food crop production, was a significant accomplishment of the recent past that helped avert large-scale hunger and malnutrition in many developing counties. Those successes, however, were beyond the reach of vast numbers of resource-poor farmers; moreover, the traditional, combined production systems, which those farmers have been practicing over generations, were ignored–or bypassed. At the same time, tropical deforestation and its disastrous consequences continued unabated. On the forestry front, despite the significant gains of tree plantations in enhancing commercial timber production, the adverse ecological consequences of monocultural, high-intensity forestry operations became evident, and the demand for ecologically compatible land-management practices increased. These developments, in tandem with scientific developments in various aspects of land management, led to a fresh look at the production and conservation benefits of traditional land-use systems. Consequently, agroforestry became recognized as the new name for the old set of practices of combined production of trees, crops, and animals on the same unit of land.

Coincident with the significant international efforts for promoting agroforestry in the tropics, the role of agroforestry in temperate regions also received careful attention, in the wake of the energy crisis of the 1970s and the recognition of the ecosystem services of trees. In North America and other temperate regions, the high rates of agrochemical and energy use in agriculture and the adverse effects of soil erosion in row-crop agriculture led to the renewed interest in the use of trees in land use and the potential role of trees as effective component in the overall solution to these problems.

Just as in agriculture and forestry, major differences exist among AF systems and their management in various tropical and temperate regions. A key aspect of tropical AF research-and-development efforts during the 1980s and 1990s was on understanding the undocumented local knowledge, including sociocultural issues, on the multitude of traditional AFS and incorporating their underlying principles in the design of improved systems and technologies. Several noteworthy efforts in tree planting activities that involve agroforestry principles and are known by terms such as farm forestry, social forestry, community forestry, trees outside forests, and many others are also abundant in the tropics. Despite the large array of trees used in tropical AFS, however, the knowledge base on their attributes such as genetic variability, physiological characteristics, cultural requirements, and market values of trees is limited.

Agroforestry Homegardens

It is estimated about 2.6 billion people produce ~ 70% of the world's food on more than 500 million smallholder farms. In general, these farms are too small and too many in many of the developing regions of Asia and Africa, and agroforestry of some form, especially the Homegardens, is a dominant type of land use and a way of life in many of those farms. In Agroforestry, the term homegarden refers to:

- Multispecies combinations with multi-strata canopies of several economically useful plants including trees, shrubs, vines, and herbaceous species, often grown in association with livestock, in relatively small landholdings around or adjacent to the home.
- Members of the household own and manage the farm; the edible produce is for household consumption, with only a small portion entering even the domestic market, except for spices and such commercial products.
- These unique farming systems represent generations of experience and traditional knowledge and provide sustenance to billions of households in the humid and subhumid tropics and subtropics.
- Several types of homegardens have been identified according to their differences in size (area), form, layout, zonation pattern, species composition, management objectives, and the dominant plant species or the level of urbanization.
- Some well-known homegardens, each with unique historical as well as contemporary characteristics, and known by their locations, include:
    - Kerala homegardens (India)
    - Java: *Talun-Kebun*, *Pekarangan* (Indonesia)
    - Kandy (Sri Lanka)
    - Chagga (Tanzania)
    - Shamba (East Africa)
    - Amazonia (Brazil)
    - *Huertos Familiare* (Mesoamerica)
    - *Streuobst* (W. Europe*)*

Another type of agroforestry system related to the homegardens is the shaded perennial system. These are managed multi-strata tree-crop associations, primarily in the tropics and subtropics. The main "crops" in these systems are trees and other perennials that are harvested frequently multiple times a year. Their products have high commercial value. The major tree crops include coconut (*Cocos nucifera*), coffee (*Coffea* spp.), and cacao (*Theobroma cacao*). Oil palm (*Elaeisguineensis*), and rubber (*Hevea brasiliensis*) are also components of AFS to a limited scale.

Agroforestry and Climate Resilience

Lately, agroforestry has received considerable attention in the context of increased interest in Climate Resilient Agriculture (CRA), an approach to sustainable use of existing natural resources for crop and livestock production to mitigate the impacts of climate change and achieve higher productivity in the long term. Lessons from traditional forms of combined production systems and investigations around the world suggest the advantages of such integrated farming systems in fulfilling these expectations, as summarized below.

- A fundamental ecological feature of mixed-species systems such as agroforestry is niche complementarity: *a larger array of species in a system leads to a broader spectrum of resource utilization and more efficient use and sharing of resources, making the system more productive.* More production means not only increased outputs of desirable products (direct benefits) but environmental and socio-economic impacts (indirect benefits) too.

- Among the benefits collectively called Ecosystem Services, carbon (C) sequestration in biomass and soils and biodiversity conservation are the two major ones. The term also encompasses socioeconomic advantages and other indirect benefits.

Carbon Sequestration

- Photosynthetic C capture by trees and its long-term storage in plant biomass such as wood that is not frequently harvested is an effective strategy for limiting the rise of atmospheric CO_2 concentrations.
- The total soil C content (~ 2,300 Pg) is three times the atmospheric pool and 3.8 times the vegetation pool of 610 Pg (1 Pg = 10*15 = one billion tons); thus, any change in the soil C pool would have a significant effect on the global C budget.
- Compared with treeless agricultural systems, AF systems have higher C seq. potential because of their higher plant diversity, larger biomass volume per unit land area, and the ability to store C in the soil-plant system for longer periods.
- It is incorrect to equate the aboveground biomass production, especially of short-duration crops, to their C seq. potential.
- The aboveground C storage rates in AFS around the world vary from 0.3 to 15.0 t ha^{-1} yr^{-1}, and the soil C stock is in the range of 30 to 300 t ha^{-1}. The best-bet estimates of soil C seq are in the range of 5–10 kg C ha^{-1} in about 25 years in tree-intercropping systems of arid and semiarid lands to 100–250 kg C ha^{-1} in about ten years in species-intensive multi-strata shaded perennial systems and the homegardens of humid tropics.
- Meta-analyses of the results from different studies have shown that overall AFS increased the SOC stocks up to 100 cm soil depth in the tropics, but not always in the temperate regions; the extent of AFS-induced SOC storage varied significantly across agro-ecological regions, age of the system, soil depth, and ecological (climatic and soil) conditions; and the potential role of AFS in climate change mitigation through SOC improvement could be more relevant in the tropical regions where the soils are known to be C-depleted than in the C-saturated temperate soils.
- Management practices including agroforestry can restore at least some of the carbon that has been lost over the decades or centuries due to land cultivation. Carbon sequestration potentials of tree taxa being highly variable, the choice of tree species and patterns of species admixture are important considerations about C sequestration in AFS.

Biodiversity Conservation

- Biodiversity (Biological Diversity) refers to all living things and the interactions among them, including the diversity within and between species as well as ecosystems. This *Gift of Nature* is seriously threatened by human activities such as deforestation and *agro-deforestation.*
- Most tropical AFS, especially the multi-strata systems, are outstanding loci for biodiversity conservation and are intrinsically capable of promoting it both aboveground and belowground. But these systems are also experiencing species losses through a process of simplification, e.g., the transformation of shaded coffee and cacao (cocoa: *Theobroma cacao*) production systems into unshaded crop monocultures with intensive management.

Other Ecosystem Services

- The tree–crop interaction effects can influence the hydrological processes including the improvement of soil water storage, enhanced infiltration rates, and reduced runoff losses. The use of vegetative buffer strips using trees and shrubs as soil conservation barriers and windbreaks are time-tested practices for controlling soil erosion and desertification.
- Results of meta-analyses linking ecosystem services of agroforestry practices to overall soil health are also becoming available to show that agroforestry, compared with crop- and tree monocultures, provides higher levels of soil-related ecosystem services.

- AFS can contribute to the enhancement of sociocultural, recreational, and ecotourism opportunities too.

In conclusion, the productivity enhancement and ecosystem services offered by agroforestry systems are scientifically well-founded. The extent to which the potential can be realized depends on several site-specific and management conditions and therefore can be highly variable. These are long-term benefits that can only be realized over longer periods, much longer than the usual cropping cycles of a season to a few years. Moreover, the manifestation of the advantages is a slow process, and its impact will be felt only gradually over time, which could be a disincentive to those expecting a rapid turnaround. Overall, the paucity of data, misconceptions about agroforestry, and the general apathy of the climate- and policy community to smallholder farming systems contribute to the lack of deserving recognition of the important role of agroforestry in management.

References

Note: All statements made above are supported by relevant scientific literature, a comprehensive source for which is the author's recently published book:

Nair PKR, Kumar BM, Nair VD (2022) *Agroforestry: Four Decades of Scientific Developments*. Springer, Switzerland. www.springer.com, ISBN-13: 978-3030753573; ISBN-10: 3030753573

Additional reference cited:

Gatti R C. et al (~144 authors) 2022. The number of tree species on Earth. PANAS (Proc. Natl Acad Sci.)119 (6) e2115329119. https://doi.org/10.1073/pnas.2115329119

1.2/Lead Paper

Agroforestry in Hindu Kush Himalayas: A Review

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Introduction

Agroforestry is a land use system where agriculture and forestry crops are combined together in a given space and time. Agroforestry is now emerging as a science. This land use option can provide a sound ecological basis for increased crop and animal productivity, more dependable economic returns, and greater biodiversity. It has an important role in reducing vulnerability, increasing resilience of farming systems and buffering households against climate related risk in addition to providing livelihood security.

The role and potentiality of agroforestry has been discussed by several authors in various publications within the SAARC countries (Gurung and Temphel, 2015) but the information on agroforestry in the Hindu Kush Himalayan Region is sparse. This paper has been developed through review of published reference materials, reports, and personal observations of the author. It deals with brief agroforestry systems and practices in countries of Hindu Kush Himalaya region, and recommends the steps that are necessary to take up for its further development in this region. Agroforestry performs all functions of forests and provides various products and services including different kinds of ecosystem services (Figure 1).

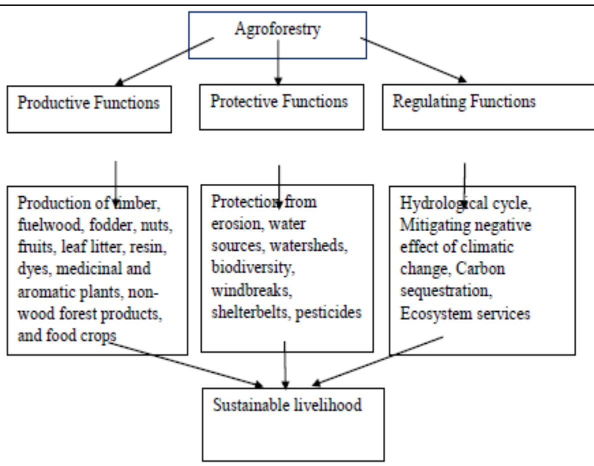
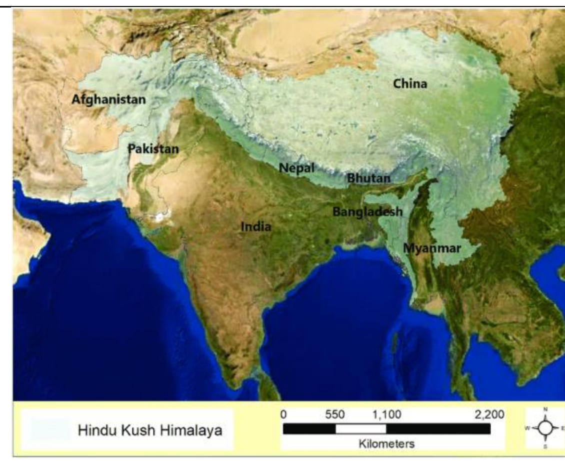


Fig.1. Agroforestry benefits



Picture 1. Countries of the Hindu Kush Himalayan Region: Source: Research Gate, 2022.

Agroforestry in Hindu Kush Himalayan Region

The Hindu Kush Himalaya is an 800-kilometre-long (500 mi) mountain range. It lies in central and South Asia to the west of the Himalayas. The range of Hindu Kush Mountains peaks isbetween 4,400 to 5, 200 m. This region embraces a total of eight countries namely Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan (Picture 1).

Agroforestry practice is very old in this region. Recorded history of planting trees goes back to as old as *Padma Purana*, a Hindu epic**.** It says *"those people who plant trees near road side s/he would feel happy in heaven as much the number of years as the tree has fruits and leaves on it"*. Raychaudhuri and Roy (1993) in Dagar (2014) mentions that some stray references occur in different texts of the Vedic literature in India about the origin of agroforestry. King (1989) has extensively covered the history of agroforestry. The objectives of practicing agroforestry in all the countries of Hindu Kush Himalayan Region are more or less the same, utilizing traditional agroforestry knowledge and technologies, learnt from their forefathers in meeting household fuel wood requirement, fodder for livestock, grazing, conserving soil and water.

Since last decade researchers seem to have put some emphasis on this discipline including its potential of multifunctional deliveries such as carbon sequestration, climate change and ecosystem services. Bhattarai et al (2016) report that all types of forests in Hindu Kush Himalayan Region provide various co-benefits in addition to carbon sequestration. It has been reported that agroforestry covers around 1 billion hectares, or 43 %, of agricultural land globally and it is estimated 1.2 billion people depend on agroforestry farming systems, particularly in developing countries (Zomer et al 2016). However, the land area covered the population engaged in agroforestry practices in Hindu Kush Himalayan Region has yet to be estimated. Depending on the countries, some of the practices is very diverse and tends to be complex. A glimpse of agroforestry systems and practices in this region are discussed below:

Agroforestry in Afghanistan

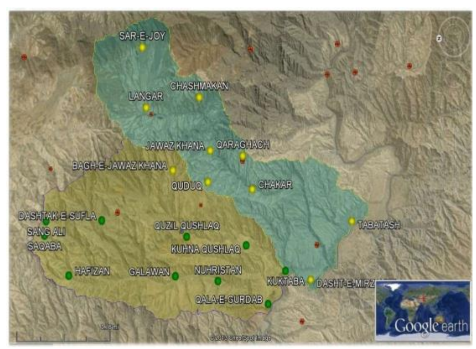
Afghanistan occupies 652, 864 km^{2}of land. Of the total land area, forests cover 12,084 km^2 (World Bank 2022). Ahmed et al (2022) report that one-fourth of the total geographical area of the country is useful in various diversified agroforestry formats.

Agroforestry practices in Afghanistan has yet to be developed. In various districts of Afghanistan, fuelwood and timber demand is very high because there is no alternate source of heating and cooking. Hence, in order to resolve the problem of fuel wood, fodder, timber and water demand, farmers are planting trees on their private farmland (Picture 2). Bradford (1990) mentions that there is a need of fast growing trees for firewood and construction activities. Most districts have planted *Populus* trees, black locust or false acacia (*Robinia pseudoacacia*), Hindustani Bakanio tree (*Ailanthus glandulose*) and Willow (*Salix* species).

During a short consultancy work in the year 2013, I have observed that farmers are planting some fast-growing tree species for fuel wood and timber production in ChakarandNahristan reforestation sites in Rustaq district (Picture 3).

I have observed that that there are ample possibilities of intercropping fruit trees such as Hing, Almond, Walnut, Mulberry, Acacia, Apricot, Pistachio and Pears and other multi-purpose tree species including Non-Timber Forest Products, fodder for livestock on private farmland. Farmers are already growing water melon underneath of tree species (Picture 4).

Picture 2. Farmers in Afghanistan prefer to plant fruit trees on their farmland, Rustaq, 2013.



Picture 3 Chakar and Nahristan Watersheds, Afghanistan

Farmers seem to prefer Walnut (*Juglans regia*), Pistachio, Mulberry (*Morus alba*), Russian Willow (*Salix* spp.) and False Acacia (*Robinia pseudoacacia*)**.** Most areas in Chakarand Nahristan reforestation sites are very dry but some sites have irrigation cannels. Trees that have been planted below the cannel appears to be are healthy and happy. Rather than planting a sole crop of Pistachio a combination of fodder and fuelwood would be better given the present condition of fuelwood and fodder shortage (Picture 5). There is a remote possibility of intercropping trees with fodder crops, agriculture cops in the community land because of sharing problems. But farmers are happy to have trees on their own farmland.

One of the possibilities is to plant bajra (pearl millet), sun flower and water melon on their private land with fast growing trees such as *Populus*, *Zizuba*, *Morus alba*, *Robinia psedoacacia* and *Salix* species

(Russian willow). Intercropping with Pistachio and Almond and other Non-Timber Forest Products (Hing) could be another viable combination. The other agroforestry options is to plant Alfalfa (*Medicago sativa)*, a perennial flowering plant, as an important forage crop, in combination of tree species. It has been reported that Alfalfa can be harvested three to four times a year and yields vary between 8 to 15 tons per hectare (Amatya, 2013). There is another possibility of intercropping trees with Hing (*Ferula assa-foetida*) especially in those villages where it grows naturally (Elkishon village).

Picture 4. Water melon under *Populus* trees, Rustaq district, Afghanistan, Picture Swoyambhu Man Amatya, 2013.

Picture 5. Three years old sole crop of Pistachio trees in Rustaq, 2013.

Agroforestry in Bangladesh

Bangladesh is located in the north-eastern part of Hindu Kush Himalayan Region. It covers 147, 570 km^2 of land area (MoFA, 2017) and forest land covers 17 percent of the total land area (Chakraborty et al 2015). But the actual area covered by trees is 6 to 7 percent only (Chakraborty et al 2015). Planting trees on homestead and along the vicinity of farmland boundaries is common in Bangladesh.

Both traditional and modern agroforestry systems are being practiced in Bangladesh. Among the traditional one the important ones are: intercropping agriculture crops with Date palm (*Phoenix dactylifea*), Palmyra palm (*Borassus flabellifer*) and Jackfruit (*Artocarpus heterophyllus*)based whereas the modern ones are introduction of tress in alley as alley cropping, riparian buffer strip, forest farming and windbreak/shelterbelt. Home garden or homestead agroforestry system is economically important practice in Bangladesh (Leuschner, and Khaleque 1987). The practice provides fuelwood, timber and other products beneficial to them. Farmers' prefer to plant trees as homestead forests mainly for heating, cooking and other purposes.

Cropland Agroforestry (CAF) practices are gaining importance in Bangladesh (Picture 6). Among the CAF tree species such as date palm (*Phoenix sylvestris*), palmyra palm (*Borassus flabellifer*), babla (*Acacia nilotica*), mango (*Mangifera indica),* khoer(*Acacia catechu)*, mahogany (*Swietenia mahagoni)*, jackfruit *(Artocarpus heterophyllus)*, *Eucalyptus* and Sissoo (*Dalbergia* sissoo) are planted on agricultural lands.

Farmers are planting various cash crops such as pine apple, turmeric underneath of tree species and introduction of various models are going on in Bangladesh (Picture 7). Although there is no separate policy that would focus on homestead forestry. Forestry extension activities in Bangladesh appears to be good. Agroforestry Department of Bangladesh. Agricultural University is working to develop sustainable agroforestry models in the country.

A survey conducted by Salam (2000) indicates that farmers whose main source of income is non agriculture, they are likely to grow trees on their farmland because purchasing cost of fuelwood is very high in Bangladesh. There are various challenges in developing agroforestry, as an alternative land use option in this country. One of them is inadequate policy support, followed by insufficient participation by the concerned farmers. It is mainly because farmers feel the insecurity of tenure once the trees are introduced on their farmland.

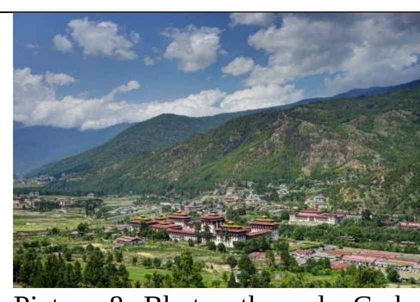
Picture 6. Intercropping trees with turmeric, Madhpur Ghar Forest area in Tangail District, Bangladesh, 2022. Photo courtesy: Dr M Zulfikar Rahman, Professor Dept. of Agricultural Extension Education, Bangladesh Agricultural University.

Picture 7. Charland agroforestry model developed by Agroforestry Department, Bangladesh Agricultural University, Bangladesh, 2022. Photo courtesy: Dr M Zulfikar Rahman, ProfessorDept. of Agricultural Extension Education, Bangladesh Agricultural University.

Agroforestry in Bhutan

Bhutan occupies 38,394 km^2 of geographical area (FAO 2010). Of this land area forest cover 69.1% (FAO 2010). Agroforestry is recently getting momentum in Bhutan. Integration of crop production, grazing animals and forest areas into a mutually supportive system is the main features of agroforestry being practiced in Bhutan. Large ruminant plays a critical role by providing draft power, manure and livestock products for sale or home consumption in this country. Transhumance system mainly in the Dzongkhags of Haa, Thimphu, Paro, Gasa, Wangdi Phodrang, Bumthang and Trashigang is also prevalent in Bhutan where nomadic herders keep yaks and sheep as their sole source of livelihood (Amatya et al 2018). Seasonal forestry grazing in semi- arid and mountainous ecosystems and Agro-silvi-pastoral systems can be seen in several locations in this country. *Eucalyptus* species are getting importance in Bhutan as fast growing fire wood tree species.

Bhutan's Forest Policy of 1974 envisaged maintaining at least 60 percent of land under forests. Subsequent revisions, however, did not provide any physical target, largely because forest cover exceeded the goal (FAO, 2010). Nonetheless, elements of Agroforestry have been recently introduced in Bhutan focusing on the potential of climate-smart agriculture, particularly the development of agroforestry, agri-silvi-pastoral systems for fodder production, organic agriculture and conservation agriculture (Tenzin, and Norbu, 2020) (cited in Dhyani et al 2021). And it is the only Carbon negative country in the world (Picture 8).



Picture 8. Bhutan the only Carbon negative country in the world. Picture courtesy: Shutterstock

Agroforestry in China

China cover about 9,602,700 km^2 of land are (Zhaohua, 1991). Forest area cover 14% of the total land area of the country. China has been practicing agroforestry for thousands of years (Lichtfouse, 2000 cited in Hong et al 2017). A comprehensive description of historical development in China can be found in

Hsiung et al (1995). The main aim is to sustain food production and income diversification. Agroforestry systems in China have been differentiated between the climatic zones. Mostly, it has been differentiated into four zones: warm temperate, arid and semiarid, subtropical and south subtropical and tropical zone (Zhaohua 1991).

Among the various agroforestry systems and practices, agro-silviculture is the dominant practice. Among this system alley cropping and home gardening are very popular (Haung*et al.,* 1997). It has been reported that in plains of North China, Paulownia trees (*Paulownia elongata*) are intercropped with wheat or bean whereas poplar (*Populus tomentosa*) is intercropped with cereals or cotton. In Xingjiang province, cotton (*Gossypium hirsutum*) is recently grown in tree stands of newly planted stands of jujube (*Zizyphus jujube*) (Wang et al 2016a, cited in Hong et al 2017). The farmland shelter belts, which are usually built together with roads and channels, vary in size from 6-20 ha. The practice of aqua silviculture is very common in wetlands. Silvo-pastoral systems are very popular in northern and western region of China.

In China's hills and mountain areas, the other types of agroforestry which are practiced in the hills and mountains vary as per the site condition. Tree species such *Juglansregia*,*Hevea brasiliensis*, *Diospyroskaki*, and *Fraxinus chinesis* are planted along with agriculture crops. Intercropping with Paulownia and Chinese dates (*Ziziphus jujube*) are being recognized as highly promising agroforestry systems in China.

A study carried out by Zhang and Liu (2022) showed that agroforestry is important in most China and its importance is strongly correlated with most sustainability indicators, including biodiversity, income diversity, resource utilization, hydrogeological preservation, and water regulation.

Rather than following traditional agroforestry practices, in China, innovative approaches are increasingly gaining momentum. Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF) has initiated intercropping mushroom particularly, edible ones like *Morchella* species and *Ganoderma lucidum*, and other medicinal plants. Consequently, cultivating mushrooms in agroforests is increasingly gaining momentum in China (Picture 9).

Picture 9. Cultivating mushrooms in agroforests can help farmers diversify agricultural products. ICRAF/AG Smith.

Agroforestry in India

India is the seventh-largest country in the world, with a total land area of 3,287,590 km² (Google data 2022). The total area covered by forest is 713,789 km2 i.e. 21.7 percent of the total geographical area of the country (Government of India 2022). India has been carrying out organized agroforestry research since the establishment of All India Coordinated Research Project in 1993. It has established the National Research Centre for Agroforestry (NRCA) in 1988. The NRCA has been mandated for agroforestry research and development throughout India. The agroforestry research conducted by the NRCA has contributed in many ways such as identifying suitable tree species for different agro-ecological zones of India for (i) biodiversity conservation; (ii) yields of goods and services to society; (iii) augmentation of the carbon storage in agro-ecosystem; (iv) enhancing the fertility of the soils; and (v) providing social and economic well-being to the people.

Agroforestry is a traditional system in India, locally known as "Kheti Badi", and is recognized as an optimal multifunctional and use system, which provides a variety of important benefits (Singh and Nayak 2022).

Agroforestry is currently practiced on 13.5 million hectares in India, but its potential is far greater. Already an estimated 65 per cent of the country's timber and almost half of its fuel wood come from trees grown on farms (Government of India 2014). A typical example of agroforestry practice in northern India is the combination of popular trees with agriculture crops (Picture 10).

Picture 10. Agroforestry practices with Popular tree. Photo courtesey: Dr. Sanjeev Chauhan, University of Agriculture and Forestry, Ludhiana, India.

Agroforestry system, in general, are ecological specific and more or less based on the natural resources of the site. There is a whole range of benefits coming from agroforestry systems. Singh and Nayak (2022) have listed a total of 14 benefits that could obtain from agroforestry ranging from products to ecological and environmental services. To accelerate the pace of agroforestry development in India, World Congress with the theme 'Trees for Life' was organized at New Delhi in February 2014. One of the important outcomes of the congress, was the promulgation of Indian National Agroforestry Policy, 2014.

Agroforestry in Myanmar

Myanmar covers a total area of 676, 578 km^2. According to FAO (2020) about 42.19 % of the country's land area (28.5 million hectares) is covered by forests. Agroforestry has a long history in Myanmar. "Taungya" hill (Taung) cultivation (ya), a system of shifting cultivation, was initiated in Myanmar. This system was introduced to regenerate Teak (*Tectona grandis*) along with cultivation of agricultural crops in forests at very low costs. The "Taungya" system was a successful agroforestry approach to establishing forest plantations in Myanmar. In 1890s, the concept was introduced in the then Chittagong (Bangladesh) areas and now it has spread to other Asian countries (Picture 11).

Picture 11. A glimpse of incorporating trees with agriculture crops in Myanmar. Photo courtesy: Livelihood and Food Security Fund, Myanmar, 2015.

Yet, agroforestry is in developing stage in Myanmar. It is mainly because farmers have limited capacity to implement agroforestry practices in the field. Hence, The World Agroforestry Centre (ICRAF) is working to develop agroforestry in Myanmar. Government of Myanmar is looking to take up an inventory of existing agroforestry practices in the country. International Non-Governmental Organizations such as European Union, Swiss Agency for Development Cooperation are also aiming to implement agroforestry to resolve the issue of food security, protection of environment and mitigating and adopting the scenario brought by climate change.

Forest Law (2018) and Rules (2018, Drafted) is the main legal framework to achieve the effective implementation of the government's forest policy and environmental conservation policy in Myanmar (*Khine*, 2021). It does not have separate agroforestry policy. However, Wangpakapattanawong (2016) reports that The Government of Myanmar is enthusiastic about the role of agroforestry in the future of the newly-democratic nation. It is looking for sustainable agroforestry practices as alternatives to shifting cultivation. Myanmar is heading towards in bringing out a National Agroforestry Strategy and Action Plan.

Agroforestry in Nepal

Nepal embraces a total of 147, 181 km^2 area in Hindu Kush Himalayan Region. Latest forest resource assessment data (DFRS, 2015) reveal that out of the total land area of the country, forest comprises around 5.96 million hectares (44.74 %). Forests is an integral part of the farming system in Nepal and agroforestry is a very old practice which is supplementing domestic requirement of fuelwood, fodder timber, nuts, fruits, medicinal and aromatic plants, in Nepal, but it was only in 1994 scientific studies on this subject matter began (Amatya 1994). It was mainly because the subject has not really been adopted by either agriculturalists or foresters. Agriculturists seem to think that trees are the domain of foresters, while foresters often feel that they should not be dealing with agriculture crops. Amatya et al (2018) has identified seven agroforestry systems and 35 practices mainly in Terai (low land) of Nepal.

The combination of tea and tree crop is an old practice where tea crop and tree species share the same piece of land. Tea crops are planted along with two tree species *Albizia procera*a nd *Albizia lebbeck* depending on the altitude. Similarly, planting cardamom (*Amomum subulatum*) under Utis (*Alnus nepalensis*) is also increasingly gaining momentum as agroforestry practice, mainly in the hills of eastern Nepal. One of the most interesting example of utilizing small piece of land in many parts of Nepal is through home gardens. They are multi-storied agroforestry system where the canopies of the component species are arranged to occupy different vertical strata. The tallest species have foliage requiring or tolerating strong light; and the shorter species have foliage requiring or tolerating shade. At ground level, vegetables and other herbaceous crops are grown. Home gardens practice is making economic benefits in eastern Nepal (Picture 12).

Picture 12. A typical home garden in Eastern Nepal with beetle nut trees along other food crops. Photo: Swoaymbhu Man Amatya, 2018.

Species diversity and plant density vary from place to place and are determined by ecological and socio-economical factors. Most home garden in low land Terai regions of Nepal, one can see Sissoo (*Dalbergia sissoo*) tress as main crop and banana, pineapple, chili, turmeric etc as secondary.

Another type of agroforestry system prevalent in the Terai regions where horticulture crops such as Mango (*Mangifera indica*) and Litchi (*Litchi chinensis*)) are intercropped with agricultural crops. The spacing for mango varies from 5 to 6 metres between and within depending on the horticulture crops introduced.

Agroforestry in Pakistan

Pakistan covers an area of 87.98 million ha. Forest cover comprises 2.99 million hectare or only 3.9 % of the land areaof the country (FAO, 2015). Agroforestry has been integral part of the farming systems in all the provinces of the country. And recently, greater attention and importancehave been given to agroforestry systems. Farmers are practicing agri-silviculture, home garden and woodlots as some of the major agroforestry systems (Picture 13).

Picture 13. Tree and food crops in Pakistan. Photo courtesy: Shailesh Tiwari, 2021.

Their preference is on *Acacia nilotica* in developing woodlots whereas *Dalbergia sissoo*, *Populus* spp. and *Eucalyptus* species are planted to work as windbreaks (Baig et al 1999). In order to reduce the speed of dust storm and to protect nearby agriculture crops, farmer plants *Dalbergia sissoo* and along field boundaries as shelterbelt species.

Agroforestry is offering opportunities for increasing biodiversity, preventing land degradation, and alleviating poverty in Pakistan (Khan et al 2017). Agroforestry systems are also being protection from wind. A study conducted in two agroforestry systems (intercropping and border cropping) by Khan et al (2017) in Bhakkar district of Punjab, Pakistan, reveals that farmers prefer to plant *Eucalyptus camaldulensis* and *Tamarix aphylla* with wheat, chickpeas (*Cicer arietinum*) or cluster beans (*Cyamous tetragocalobe*). The most important positive perception of farmers about these agroforestry systems is protection of nearby crops from dust storms. As tree crops are involved in agroforestry systems and practices, the gestation period is high i.e. only rich farmers who can wait for 3-4 years for harvesting are more likely to take the advantage of agroforestry. On the contrary, poorer farmers who are totally dependent on subsistence agriculture and cannot afford the high initial cost of agroforestry establishment may be not willing to take up agroforestry practices.

Pakistan has already launched many forestry extension projects under different slogans (e.g. ‘‘farm forestry initiatives for farmers’’, ‘‘social forestry for social development”, and ‘‘community forestry for sustainable communities’’. Nonetheless, some of the main constraints for enhancing agroforestry in Pakistan are: (i) lack of markets and supplies, (ii) land designation, and (iii) technical assistance. Crop damage from insect pests, diseases and birds (Jamilu et al 2014) are also substantial. There is high opportunity of wood carving in Pakistan but skilled use of wood-working are limiting the opportunities and for value addition. There is a poor communication and links between research and extension in terms of agroforestry development

Major agroforestry systems and practices in Hindu Kush Himalayan Region

It has been observed, in general, that agroforestry plays a crucial role in areas where forest areas are small but there is high demand of forest resources because of the nature of traditional livelihood. Forest area in Afghanistan is very less in comparison to other Hindu Kush Himalayan Region. Consequently, there is a very high demand of fodder and leaf litter for livestock development, fuelwood for heating and cooking purposes. International Centre for Integrated Mountain Development (ICIMOD) has worked on several issues in Hindu Kush Himalayan Region including land cover map. It reports that the mountainous areas of Hindu Kush range are mostly barren or at the most sparsely sprinkled with trees and stunted bushes.

The review reveals that among the Hindu Kush Himalayan countries, Afghanistan has the lowest forest cover while Bhutan has the highest (Table 1).

Table 1. Forest area coverage in the Hindu Kush Himalayan Region

Country	Total geographical area (km^2)	Total forest area (km^2)	Percentage of forest cover	Information source
Afghanistan	652, 864.00	12, 084.00	1.85	World Bank, 2022.
Bangladesh	147, 570.00	25,086.90	17.00	MoFA, 2017. Chakraborty *et al.*, (2015).
Bhutan	38,394.00	26,530.25	69.10	FAO, 2010.
Chian	9,602,700.00	1,344,378.00	14.00	Zhaohua (1991).
India	3,287,590.00	713,789.00	21.70	Google data (2022) FSI, 2022.
Myanmar	676, 578.00	285,000.00	42.19	FAO , 2020.
Nepal	147, 181.00	59,600.00	44.74	FRTC, 2018.
Pakistan	879,800.00	29,900.00	3.90	FAO, 2015.

The objectives of practicing agroforestry in all the countries of Hindu Kush Himalayan Region are more or less are the same i.e meeting household fuel wood requirement, fodder for livestock, grazing, conserving soil and water utilizing traditional agroforestry knowledge and technologies, learnt from their forefathers. However, depending on the countries, some of the practices is very diverse and tends to be complex. Based on their composition: agri-silivi-cultural system, silvi-pastoral system, agri-silvi-pastoral system, and multipurpose tree plantation system are the major types of agroforestry systems in the Hindu Kush Himalayan Region. Some other agroforestry systems include improved fallows, alley cropping, scattered trees on cropland, live fences, wind breaks, trees along boundaries, contour vegetation strips, trees and shrubs on terraces, shifting cultivation, and cultivation of tea, cardamom, coffee and medicinal plants under trees.

The following traditional and improved agroforestry systems (with new concept) and practices are prominent in the Hindu Kush Himalayan Region (Table 2).

Table 2. Country wise prominent agroforestry systems and practices in Hindu Kush Himalayan Region

Country	Type of agroforestry systems and practices	Preferred tree species	Preferred crop species
Afghanistan	Agri-silviculture, Home gardens.	*Populus*, *Robinia pseudoacacia*, *Ailanthus glandulose* and *Salix* species	Pearl millet, Sun flower, Water melon, Alfalfa (*Medicago sativa*) and Hing (*Ferula assa-foetida*)
Bangladesh	Agri-silviculture Home gardens Aqua forestry Apiculture with trees Alley cropping Riparian buffer strip Windbreak/Shelterbelt	Date palm (*Phoenix sylvestris*), Palmyra palm (*Borassus flabellifer*), *Babla*(*Acacia nilotica*), Mango (*Mangifera indica)*, *Khoer*(*Acacia catechu)*, Mahogany (*Swietenia mahogany)*, Jackfruit *(Artocarpus heterophyllus)*, *Eucalyptus* and Sissoo (*Dalbergia* sissoo)	Winter wheat, maize, colocassia leaf, tobacco, sugarcane,
Bhutan	Agri-silviculture, Silvo-pastoral at high altitude, Agro-silvi-pastoral	*Eucalyptus*, *Ficus* spp.,	Maize, wheat, colocassia leaf,
China	Agri-silviculture, Farmland shelter belt and forest networks, Home gardens, woodlots.	Paulownia (*Paulownia elongata*) and Populus (*Populus tomentosa*), *Juglansregia*,*Hevea brasiliensis*, *Diospyroskaki*, and *Fraxinus chinesis*	Wheat, cotton (*Gossypium hirsutum*), Zinger
India	Agri-silviculture, Horti-silvicudlture, Home gardens, Shifting cultivation, Raising cardamom under Alnus trees,	*Tectona grandis*, *Dalbergia sissoo*, *Populus* spp., *Salix* spp., *Eucalyptus* spp., *Acacia nilotica*, *Azadirachta*	Wheat, millet, buck wheat maize, sugarcane, tobacco. zinger, turmeric.

	Wood lots, Shelterbelts/ Mangroves, Silvo-fishery Apiculture Coffee, tea under tree crops	*indica*, *Pongamia* (*Calatropis gigantum*), *Albizia* spp.	
Myanmar	Agri-silvicullture Home gardens Tangya	Teak (*Tectona grandis*)	Maize, wheat colocassia leaf.
Nepal	Agri-silviculture, Agro-silvo-pastoral, Silvo-pastoral, Silvo-fishery, Home garden, Woodlots, Apiculture, Silvo-horto practices. Tea under tree crops.	*Dalbergia sissoo, Eucalyptus, Melia azedarach, Ficus* spp., *Albizia* spp.	Wheat, maize, sugarcane, tobacco. zinger, turmeric, buck wheat,
Pakistan	Agri-silviculture, Home garden and Woodlots.	*Acacia nilotica*, *Dalbergia sissoo*, *Populus* spp. and *Eucalyptus s*pecies	Wheat, maize, sugarcane, tobacco. zinger, turmeric.

Contributions of agroforestry systems

In all the regions of Hindu Kush Himalaya agroforestry practices are contributing in both the tangible and intangible forms. Recently, agroforestry practices have been increasingly being recognized to contribute to climate change. A review carried out by Dhyani *et al.* (2021) report that agroforestry, as a science, has ample potential of mitigating climate change within south Asian countries.

Trees capture and store atmospheric carbon into its trunks, branches, leaves, and roots. It is said that trees having large trunks, dense wood are the best absorber of carbon. Trees having large leaves and wide crowns also help to absorb atmospheric carbon. It is also said that trees store most carbon during their first decades. Fast growing trees are more desirable than the slow growing ones. It is better if they are indigenous as this helps them to thrive in the native soil, having low maintenance cost. Bhattarai et al (2016) report that all types of forests in Hindu Kush Himalayan Region provide various co-benefits in addition to carbon sequestration. It is said that agroforestry is one of the activities that help sequester carbon from atmosphere. The issues of agroforestry and carbon neutrality have been elaborately discussed by Amatya (2022). A study conducted by He et al (2022) suggest that enhancing agroforestry carbon sinks is one of the pathways on China's long-term low carbon transition pathways and strategies.

In terms of agroforestry, farmers grow native tree species and protect them to maintain their farmland productivity. Livestock is one of the important components in farming system. They normally raise animals for human consumption, cash income and for farm yard manure. Types of agroforestry systems vary as per the region. However, the information on the economic benefits derived from different types of systems and practices are scanty. Nonetheless, Singh and Nayak (2022) have shown that timber based on-farm systems are meeting more than 60% of the county's timber demand in India. It has been reported that in Yamuna Nagar, Haryana state, 15,000 tons of Popular woods are auctioned daily and 60,000 labors are employed per day (Bhojvaid and Singh 2005) in plywood manufacturing activities. It has been estimated that each hectare of land under agroforestry system generates employment for 450 labor per annum (Bhojvaid and Singh 2005). State Government makes one million US $ revenue per month.

In addition, fruit based, nut based, multipurpose tree species based, fodder based, non-timber forest based, reactivation of traditional watersheds and rehabilitation of degraded lands, and reduction of soil erosion are some of the important contributions that agroforestry systems are providing in various ecological zones of India. Carbon sequestration in homestead agroforestry can be considered permanent as complete biomass removal does not occur in comparison to other practices (Nath and Aziz 2013). Some Pine species are said to absorb more carbon than others Pütsep (2021. It has been reported that Teak (*Tectona gandis*) tree, has the highest carbon sequestration capacity.

Unfortunately, Pine species are not favored by agroforestry practitioners of almost all countries of Hindu Kush Himalayan Region because these trees tend to make soil acidic. Consequently, other species hardy thrive underneath of *Pines*. Similar is the case with Teak trees. Trees having lateral rooting properties (such as Ficus) are also not desirable in agroforestry practices as they compete with agriculture crops. One of the essential features of agroforestry tree species, in my opinion, is that these trees should have deep tap root system so that there is no or little competition for moisture, nutrients both for tree and agriculture species. It has been reported by Boumenjel et al (2021) that *Moringa oleifera* (drum stick) is a promising choice in arid zones of Tunisia. Similarly, Gliricidia (*Gliricidia sepium*) is a good species which supports agriculture production and provides services to environment. We need to test these trees in our environment.

Many countries of the world are now working on REDD+ concept (Reducing Emissions from Deforestation and forest Degradation) and have adopted UNFCCC definition which directly or indirectly contribute to reduce emission from forest degradation and deforestation through various ways and agroforestry is one such activity. A review on "Sustainability Challenges" edited by Mbow (2014) and his colleagues recently showed that in addition to carbon benefits, agroforestry has the potential to deliver sustainable development goals. All types of trees store some amounts of carbon as above ground biomass and in soil and the same is true in agroforestry systems. But which tree species store more Carbon and at which site, it is yet to be identified in most Hindu Kush Himalayan countries.

Issues on the development of agroforestry systems and practices in Hindu Kush Himalayan Region

Some of the major issues found in the development of agroforestry systems and practices are outlines below:

Ownership of Agroforestry discipline: Who has to take the lead in this discipline? is creating some confusion even in the Government entities. For example, in Nepal, it was only in 1987, agroforestry has been initiated by the Department of Forest Research and Survey as one of its major program. Similar is the case with Bangladesh and Pakistan. ICRAF has also noticed that in various countries of the region, agroforestry discipline did not flourish in the past owing to the sectoral division between forestry and agriculture departments.

Nature of the subject matter: Agroforestry is not a simple technique of growing trees and agriculture crops in a same piece of land if we think of commercializing its products and services in terms of their sustainability in perpetuity. It is a complex process and needs a multi-disciplinary approach such as forestry, agronomy, animal husbandry, anthropology, economics, and sociology depending on the nature agroforestry being employed and the expectations of the farmers and entrepreneurs.

Regulatory framework for developing agroforestry: Among the Hindu Kush Himalayan Region, agroforestry practices are technologically advanced in India whereas it is slowly gaining momentum in other. Except India and Nepal, all other countries of this region rely on their respective Forest Act and Regulations for regulating products obtained from agroforestry systems and practices. And in many cases, farmers have reservations in promoting agroforestry on their farmland.

Financing mechanism for prompting agroforestry: Financial benefit is an important driving force in determining whether farmers adopt an innovation. This is true in case of agroforestry practices. A farmer is more likely to be interested in the personal benefit of producing a wood crop that can be sold at a profit in 5–8 years, rather than by a national need to bridge the gap between wood supply and demand. On the top of it, farmers may not have the financing mechanisms already present but are not available to them.

Way forward

Some of the strategies and activities that should take up for the promoting, developing and enhancing agroforestry are as follows:

Increase in adoption rate: Although the adoption rate of agroforestry is increasing in some of the Hindu Kush Himalayan countries for example, India, Nepal, Bangladesh, some are lacking behind. To increase agroforestry adoption rates, respective government should bring a separate agroforestry policy that would help farmer to adopt various types of agroforestry practices, strengthen farmers' knowledge of every stage of agroforestry through extension services. Agroforestry products marketing is an important issue. One is the regulatory hurdles and the other is small scale of marketable products. What has been experienced that bringing policies are not adequate enough for promotion, development and enhancement of any practice, it needs to be implemented and practitioners should feel their voices are heard by the respective governmental entities.

Use of Information Communication Technology (ICT) in agroforestry (Extension Mechanism)

Information communication technology is increasingly becoming important to monitor the various agroforestry activities. Barthakur(2014) reports that Tata Consultancy Services (TCS) has developed a mobile agro-advisory system called mKrishi? to improve agricultural productivity and GeoVun – a GIS based technology for tracking forest cover and preservation of biodiversity in India. That sort of programs should be developed and implemented as far as practicable in all the countries of the Hindu Kush Himalayan Region. Print and electronic media outlets can also be used to publicize the benefits and problems associated with agroforestry. For example, in Pakistan, the AGFORWARD website (www.agforward.eu) has been effective in promoting agroforestry (Burgess and Rosati 2018). Throughout the Hindu Kush Himalayan Region, several languages are spoken and scores of dialects exist. Hence, delivery of the message only in English language may not yield adequate result. As far as possible, for more effective delivery, messages should be developed in the local language.

Focus on problem oriented research

Our focus should also be on the problem-orientated research and implementation of its results. Farmers are reluctant to plant tree species on their farmland because of shade effect and other unforeseen problems (disease and pest). Identifying suitable combination of tree and agriculture crop species that would reduce tree crop interaction, for a given locality, would encourage farmer to take up this practice. Reducing the dependence on external input such as pesticides may encourage to adopt agroforestry activities. Species such as Neem, Pongamia, Aak (*Calatropisgigantum*) and Bakaino (*Melia* spp) have some insecticidal properties which can be utilized as pesticides. Demonstration plots should be established which may act as a learning platform within a given area/ villages. Academic institutions can be instrumental in developing appropriate propagation and nurseries techniques.

Present capacity of government institutions may not be adequate enough to cater this discipline and its increasing innovations. Refresher trainings are needed. The concept of materializing "high value and low volume" productions both in case of tree and agriculture components including the integration of Non-timber Forest Products and Medicinal and Aromatic Plants, is the need of the day.

The role of National and International Organizations

Major Governmental and Non-Governmental Organizations are involved in the promotion of agroforestry in the Hindu Kush Himalayan Region. Almost all government institutions within the Hindu Kush Himalayan Regionis taking lead in developing agroforestry. The Seventy-eighth session of Economic and Social Commission for Asia and the Pacific (ESCAP, 2022) has reviewed the implementation of the 2030 Agenda for Sustainable Development in Asia and the Pacific. The review highlights the opportunities in several sectors and emerging initiatives for raising climate ambition in the region, including blue carbon, ecosystems-based climate solutions, energy, sustainable cities, transport, trade and investment, and business.

We have institutions like ICIMOD and other Non-Governmental Organizations that are devoted in enhancing the agroforestry discipline. They should take a lead role in identifying agroforestry practices that are suitable for farmers and serve ecological benefits to the society. UN agencies like FAO, UNESCAP should also be instrumental in identifying tree species that absorb carbon and its combination for successful agroforestry practices. Smoke is creating human life difficult. It has been experienced that due to the burning of agriculture debris in Punjab, in early November 2022, sky of Delhi was full of smoke and schools were closed. Offices were requested to run from their own residence. We all know that all trees, more or less, absorb atmospheric carbon. It would be nice if we can identify agroforestry species that absorb more carbon, in a given site, without lowering the agriculture productivity.

Observing Agroforestry Days

We are observing many International days focused on some specific topic. What has been experienced that observing these sort of 'International Day' has created additional awareness learning and motivation on the concerned subject matter. My gut feeling is that we should start observing Agroforestry Day. It is the only way to have both forest and their products, all types of ecosystem services, and agriculture crops in perpetuity.

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References

Ahmed F, Talukdar, NR, Goparaju, L and Rizvi J 2022. Satellite-Based GIS Evaluation of Land to Scale Agroforestry Restoration Planning in Afghanistan. *World Agroforestry News*, 2022.

Amatya SM 1994. Research needs in Community Forestry. In: Proceedings of the Workshop on Research needs in Community Forestry. Compiled by Dr. S.M. Amatya, Research Officer, Forest Research and Survey Centre. October 1994. Forest Research and Survey Centre, Kathmandu, Nepal; Asia-Pacific Agroforestry Network, Bogor, Indonesia.

Amatya SM 2013. Consultancy report on Reforestation and fuel production within LIPT-III project:Terre des hommes**,** Livelihood Improvement Program (LIPT III)**,** Rustaq, Afghanistan, 2013.

Amatya SM, Cedamon E and Nuberg I 2018. Agroforestry Systems and Practices in Nepal. Revised Edition. Agriculture and Forestry University, Rampur, Nepal, 108pp. + xviii

Amatya SM 2022. Agroforestry Potential for Carbon Neutrality. In: Proceedings of the Indian Ecological Society International Conference 2022. Edited by Peshin R, Kaul V, Perkins, J.H., Sood KK, Dhawan, A.K., Sharma M, Yangsdon S, Zaffar O, and Sindhura K 2022. *Sustainable agricultural innovations for resilient agri-food systems.* The Indian Ecological Society, Ludhiana, India.

Baig MB, Akbar G, Straquadine GS and Razzaq A 1999. Agroforestry extension and technology transfer to farmers in Pakistan. *J. Sci Vis* **5**(1)**:**42–50.

Barthakur R 2014. Agroforestry in Myanmar: A long term sustainable solution. *Myanmar Matters* **06:**

Bhattarai N, Joshi L,Karky BS, Windhorst K and Ning W 2016. Potential synergies for agroforestry and REDD+ in the Hindu Kush Himalaya. ICIMOD Working Paper 2016/11. Kathmandu: ICIMOD.

Bhojvaid PP and Singh VP 2005. Agroforestry provides opportunities for economic development and sustainable use of forest resources in Haryana, India. In: *Proceedings of the 22nd IUFRO World Congress*, 8-13 August, 2005, Brisbane, Australia.

Boumenjel A, Papadopoulos A and Ammari Y 2021. Growth response of *Moringa oleifera* (Lam) to water stress and to arid bioclimatic conditions. *Agroforestry Systems* **95**(9) :823–833.

Bradford LE 1990. Agroforestry in Afghanistan. Development Alternatives, Peshawar, Pakistan, Afghanistan Agriculture Sector Support Project. 1999.

Burgess PJ and Rosati A 2018. Advances in European agroforestry: results from the AGFORWARD project. *Agrofor Syst* 92: 801–810.

Chakraborty M, Haider MH and Rahaman MM 2015. Socio-economic Impact of Cropland Agroforestry: Evidence from Jessore District of Bangladesh. *International Journal of Research in Agriculture and Forestry*, Volume 2, Issue, 1, January 2015, pp 11-20.

Dagar JC, Singh A.K and Arunachalam A 2014. Agroforestry Systems in India: Livelihood Security & Ecosystem Services, 2014.

DFRS 2014. State of Nepal's Forest. Department of Forest Research and Survey, Government of Nepal. 2015.
Dhyani S, Murthy IK, Kadaverugu R, Dasgupta R, Kumar M and Adesh Gadpayle K 2021. Agroforestry to Achieve Global Climate Adaptation and Mitigation Targets: Are South Asian Countries Sufficiently Prepared? *Forests* 2021, 12, 303.
FAO 2010. Asia-Pacific Forestry Sector Outlook Study, Food and Agriculture Organization of the United Nations. RAPA Publication 2012/10.
FAO 2015. Global forest resource assessment 2015. Desk Reference. Food and Agriculture Organization of the United Nations. Rome. (It is not found in the text)
FAO 2020. The Global Forest Resources Assessments (FRA) Report. Rome, 2020.
ESCAP 2022. Provisional Agenda. Seventy-eighth session of Economic and Social Commission for Asia and the Pacific, Bangkok.
Government of India 2014. National Agroforestry Policy. Department of Agriculture & Cooperation, Ministry of Agriculture, New Delhi, 2014.
Government of India 2022. The state of India's forests: Forest Survey of India, Government of India, Ministry of Environment and Climate Change, 2022.
Gurung TR and Temphel KJ (Eds). 2015. Technological advancement in agroforestry systems: Strategy for climate smart agricultural technologies in SAARC Region
Hong Y, Heerink N, Jin S, Berentsen P, Zhang L, Wopke and Werf, van der 2017. Intercropping and agroforestry in China – Current state and trends, *Agriculture, Ecosystems & Environment,* Volume 244,2017,Pages 52-61.
Hsiung W, Yang S and Tao Q 1995. Historical development of agroforestry in China. Agroforestry Systems, Volume 30. Pp 277-287.
Huang W, Kanninen M, Xu Q and Huang B 1997. Agroforestry in China: Present State and Future Potential. Royal Swedish Academy of Sciences. Vol. 26. No. 6, pp 394-395.
Jamilu A, Ammar H and Gardish DM 2014. Factors upsetting agroforestry system in Swat, Pakistan. Int J *Agrofor Silvic1*:86–92.
He J, Zheng L, Zhang X, Wang H, Dong W, Du E, Chang S, Qu X, Gue S, Tian Z, Gu A, Teng F, Hu B, Yang X, Chen S, Yao M, Yuan, Z, Zho L, Zhao X, Li Y, and Zhang D 2022. Towards carbon neutrality: A study on China's long-term low-carbon transition pathways and strategies. Environmental Science and Ecotechnology. **9**, January 2022.
Khan M, Hafiz ZM, Abbas G and Damalas CA 2017. Agroforestry Systems as Alternative Land-Use Options in the Arid Zone of Thal, Pakistan. *Small-scale Forestry.*
Khine K 2021. Forest and Forestry in Myanmar: an overview of forest laws, policies, and strategies. Asian Forest Cooperation Organization (AFoCO), *Forestry News*, December, 2021. Myanmar.
King KFS 1989. Agroforestry Systems in the Tropics. Forestry Sciences, **31**. Edited by Nair, P.K.R (1989) Kluwer Academic Publishers.
Leuschner WA and Khaleque A (987. Homestead agroforestry in Bangladesh. *Agroforestry Systems*, **5**: 131-151pp.
Mbow C, Neufeldt H, Akong PM, Luedeling E and Kowero G 2014. Current Opinion in Environmental Sustainability. *Sustainability* **6**, 78-82.
MoFA 2017. Bangladesh Facts. Ministry of Foreign Affairs, Government of Bangladesh, 2017.
Nath TK and Aziz M 2014. Homestead Agroforests in Ecologically Critical Area (ECA) of Cox' Bazar – Teknaf Peninsula, Bangladesh: Implications for Climate Change Mitigation. In: Proceedings of International Workshop on Women in Agroforestry, 28-29 November 2013, Kathmandu, Nepal 2014. Edited by Amatya, S. M.; Das, A. K.
Pütsep A 2021. Sustainable Lan Management. Which Trees absorbs the most Carbon? Single.Earth, October 11, 2021.
Raychaudhuri SP and Roy M 1993. quoted in Dagar, J. C., Singh, A. K. Singh and Arunachalam, A. (2014). Agroforestry Systems in India: Livelihood Security & Ecosystem Services, Advances in Agroforestry, J. C. Dagar *et al.* (eds). Springer India 2014.

Salam MA, Noguchi T and Koike 2000. Understanding why farmers plant trees in the homestead agroforestry in Bangladesh. *Agroforestry Systems* 50: 77-93, 2000.
Singh VP and Nayak D 2022. Agroforestry for ustainable ivelihoods, food and nutritional security and environmental protection. In: Proceedings of the Indian Ecological Society International Conference 2022. Edited by Peshin R, Kaul V, Perkins JH, Sood KK, Dhawan AK, Sharma M, Yangsdon, S, Zaffar O and Sindhur. K. *Sustainable agricultural innovations for resilient agri-food systems*. The Indian Ecological Society, Ludhiana, India.
Wangpakapattanawong, P 2016. A new hope for agroforestry in Myanmar. The World Agroforestry Centre, 2016.
World Bank 2022. Integrating Climate Change into Nepal's Development Strategy Key to Build Resilience, Press release September 15, 2022.
Zhang M and Liu J 2022. Does Agroforestry Correlate with the Sustainability of Agricultural Landscapes? Evidence from China's Nationally Important Agricultural Heritage Systems. *Sustainability* 2022, 14.
Zhaohua, Z, Maoyi, F and Sastry CB 1991. Agroforestry in China - An Overview
Zomer R, Henry Neufeldt, Jianchu Xu, Antje Ahrends, Deborah Bossio, Antonio Trabucco, Meine van Noordwijk and Mingcheng Wang 2016**.** Global tree cover and biomass carbon on agricultural land: the contribution of agroforestry to global and national carbon budgets**.** *Scientific Reports*, 6. 2016.

1.3/Lead Paper

Tree Based Land-use Systems and Ecosystem Services

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Abstract: Ecosystem services are natural processes and functions which are essential for livelihood and human well-being. Ecosystem services are generally defined as services that are provided by the nature that benefit people in all societies. Trees either individually or in form of forest or agroforestry provides varied range of ecosystem functions which are fundamental in sustaining life on Earth. Changes in Ecosystem Services (ES) affects livelihood, jobs, migration, and political and social conflict and many other activities of humans. The ES concept focuses on ecosystem preservation as a whole rather than on managing single or a small group of natural resources and their uses, and therefore, it enhances understanding of environmental problems and promotes solutions within local decision making. Understanding ecosystem services provided by tree based landuse system and valuation of such services will go in a long way in providing compensation for removal of tree based landuse systems for development work or it can also act as a deterrent for destruction of the forest wealth.

Keywords: Agroforestry, tree based landuse system, provisioning services, regulating service, cultural service and supporting services

Introduction

Earth supports more than 3 trillion trees. However, this number is rapidly decreasing and about 15 billion trees are lost a year to varied activities like toilet paper, farmland expansion, timber, and other human requirements (Crother et al 2015). Trees either individually or in form of forest or agroforestry provide a different ecosystem service which forms basis to sustaining terrestrial systems. Ecosystem services refer to the conditions and processes through which natural ecosystems maintains and fulfill human life (Daily, 1997). Changes in Ecosystem Services impact livelihoods, jobs, migration, and even political and social conflict and other activities of humans. Realizing the importance of ecosystem services being provided by trees as individual or in group it has become imperative to identifying the services provided by trees individually and develop methods to quantify and attach value to these ecosystem services to financially provide compensation to land owner/managers for conserving and restricting from land-use practices which destroys forest. In this paper attempt had been made to identify different ecosystem services provided by the tree or tree based landuse system. The valuation of such services will go in a long way in providing compensation for removal of tree based landuse systems for development work or it can also act as a deterrent for destruction of the forest wealth.

Ecosystem functions provides important support to provisioning of ecosystem services which are required to sustain human populations (Foley et al 2005), regulate pest control, support pollinating services, habitats for flora and fauna, provide fuel and fibre and many other services provided by trees based landuse systems. Early user of the concept of ecosystem service (Ehrlich and Mooney, 1983; Westman, 1977) used it to demonstrate the reduction of natural resources by human activities which can reduce the capacity of ecosystems to fulfill important services. Thereafter, ecosystem services payments (Wunder, 2008) were evolved to provide compensation land owners for conserving ES and avoiding felling and other destructive land-use practices. Recently ecosystem services are known to have co-produced by socio-ecological processes—that are a combination of natural, financial, technological, and social capital which require human intervention (Biggs et al., 2015; Palomo et al., 2016). Conservation of biological diversity and related areas address improvement of ecosystem services (Lefcheck et al 2015). Agriculture and forestry are being managed as two separate landuses which are sometimes antagonistic practices, resulting into conflicts related to society and environment. However, these two are interlinked with each other. Worldwide, agriculture is known to be responsible for deforestation (Gibbs et al., 2010), and approximately

80% of forest loss (Kissinger and Herold, 2012). These losses results is approximately 11% of total global carbon emissions (an emissions of 4.3–5.5 Pg CO_2 eq. yr^{-1}) (Smith et al 2014; Goodman and Herold 2014).

Ecosystem services (ES) are natural processes and functions that are essential for human well-being and livelihood (Wondie 2018; Li et al 2020). Ecosystem services are the services provided by the natural environment that for the benefit of people. ES impacts directly and indirectly on human well-being, culture, and economic system (Feng et al 2018; Ma et al 2020). Change in ES impacts livelihoods, jobs, migration, and political and social conflict (WHO, 2018; Rodríguez-Robayo et al 2020). Overall, the ecosystem provides a number of goods and services termed as ecosystem services (ES) which satisfies multiple needs of multi-stakeholders (humans as well as other organisms). The ES concept considers ecosystem as a whole rather than managing single of small group of natural resources and uses, and therefore, it improves knowledge of environmental problems and promotes sustainable solutions for local decision making (Posner et al 2016). The Millennium Ecosystem Assessment (MEA), which is a major UN-sponsored effort to see the impact of human actions on ecosystems and human well-being. The MEA had identified four categories of ecosystem services which are provisioning, regulating, cultural and supporting services. The enlisting of the ecosystem services under four different categories are given in table 1. These services are indicative and there may be many more services which a tree and tree based landuse system may provide. Few ecosystem services provided by tree based landuse system are discussed.

A. Provisioning Services

The provisioning services include the materials which provide direct/tangible benefits to human being for example food, fodder, timber, fuelwood, fibre, natural medicines *etc*. A provisioning service is a benefit which can be obtained by human from nature. Other than food, other provisioning services are water, timber, wood fuel, natural gas, oils, plants that can be converted into clothes and other materials, and medicinal benefits.

Table 1. Ecosystem functions and services

Provisioning services	Regulating services	Supportive services	Cultural services
Water supply	Air quality regulation	Nutrient cycling /soil fertility	Recreation
Food	Climate/microclimate regulation	Net primary production /Photosynthesis	Aesthetic
Ornamental resources	Disturbance regulation	Pollination and seed dispersal	Science and education
Genetic resources	Biodiversity	Habitat	Spiritual and historic
Medicinal resources	Water regulation	Hydrological cycle	Ecotourism
Raw materials	Soil retention/ Erosion control	Biological nitrogen fixation	Ornamental
Firewood	Waste regulation		
Fodder	Nutrient regulation		
Manure	Biocontrol		
Gums	Carbon sequestration		
Genetic resources	Flood control		
Wood/fibre	Pollination		

Source: Farber et al (2006) with modification

The intangibility of provisioning services perhaps reduces its regulatory services due to owner's perception of provisions (food or medicines) provided by landuse system as most vital for his/her wellbeing and livelihood even if it is providing many services other than provisional (Blanckaert et al 2004; Caballero-Serrano et al 2016). Global compilation of provisioning services provided by trees was carried out. These studies showed that most of the results had positive (52%) or neutral (47%) impact of presence of trees on production of yields of food crops. However, large variability has been observed. In America presence of tree enhanced food yields in 58% studies; while in Asia majority of studies (48%) showing reduced food yields due to tree presence (James et al 2017).

Provisioning services provided by homegarden across different countries has been compiled (Table 2). It was found that homegardens provide food, fodder, timber, medicine and other services.

Table 2. Provisioning services on homegardens (HG) from different regions

Country (region)	Number of HGs surveyed	Total number of Species	Predominant plant species category	Source
Austria, (Osttirol)	196	94	Ornamental, spices, fruits	Vogl-Lukasser and Vogl (2004)
Bangladesh (Northern part)	80	62	Edible, medicine, fuel and timber	Roy et al (2013)
China (Beijing municipality)	104	278	Edible, ornamental, medicine	Clarke et al (2014)
Ecuador (Amazonian)	138	484	Edible, medicine, Ornamental	Caballero et al (2016)
Ethiopia (Janithenan District)	48	69	Edible, medicine, ornamental	Mekonnen et al (2014)
Iran (Bash district)	192	97	Edible, ornamental, medicine	Schadegan et al *(*2013)
India (North Bengal)	100	142	Edible, fuel and timber, ornamental	Subba et al *(*2015)
Sri Lanka (Western parts)	106	289	Ornamental, food, medicine	Kumari et al (2009)
Mexico (Tehuacan-Cuicatlan Valley)	30	281	Ornamental, edible, shade, medicinal	Blanckaert et al (2004)
India (North-Eastern part)	50	122	Edible, medicine, timber, ornamental	Das and Das (2005)

Provisioning services is provided by trees growing in parks and institutional areas in cities. In a study, total observed species were 61 which delivered provisioning services to city residents. Out of these, 43 yielded timber (71.67%), 38 provided food (mainly fruit, 68.25%), 32 were used as fuel wood (50.79%), 31 yielded fodder (49.20%), 19 had medicine value (30.16%), nine yielded tannin (14.28%), four yielded gum & resin (6.35%) and only one produced floss (1.59%) (Pradhan et al 2020).

B. Regulatory services

Ecosystems provide basic services which make life possible for human being. Plants keep air clean and filters water, waste is decomposed by bacteria, flowers are pollinated by bees, and tree roots binds soil thus prevent soil erosion. These activities work intendum to make an ecosystem sustainable, functional, and resilient to change. A regulating service is benefit which we drive through ecosystem processes that moderates natural phenomena. pollination, decomposition, water purification, erosion and flood control, and carbon storage and climate regulation are parts of regulating services.

There are seven ecosystem services that need to be regulated: sequestration of carbon, improved soil fertility, reducing/containing soil erosion, control of water and wind, pests, and pollination (MEA 2005). In 2010, in Bronx's 2,470 hectares tree cover removed about 5.1 tons yr^{-1} of PM2.5, thus providing health benefits amounting \$6.9 million yr^{-1}. In 2030 with modeling high mortality tree scenario, amount of pollutants removal of PM2.5 would be 5.6 tons yr^{-1} (\$7.2 million yr^{-1}); For average tree mortality the removal would be 5.9 tons yr^{-1} (\$7.3 million yr^{-1}). The pollutant removal would be 6.2 tons yr^{-1} (\$7.4 million yr^{-1}) when modeling low tree mortality (Nyelele et al 2019). With same area with 2010 tree cover, total runoff of 2.5 billion ft^3yr^{-1} was assessed. Presence of trees were able to avoid 60 million ft^3yr^{-1} of runoff

(9,830 ft^3 $acre^{-1}$ of tree cover) which is equivalent to 2.4% reduction which costs about $4 million/yr protection service provided by tree presence. Studies elsewhere also reported reductions in runoff between 2% to 7% (Vargas et al 2008). In Phoenix, AZ, an area of 22,146-acres of tree cover was able to reduce runoff by 91.7 million ft^3 (4,140 ft^3 $acre^{-1}$ of tree cover), valuing $ 6.1 million (Davey Resource Group, 2014). The trees in NYC's street reduced the runoff by 890.6 million gallons annually, valuing $35.6 million (MillionTrees NYC, 2017). Larger areas under grass and trees permits runoff to infiltrate in the soil profile, as compared to cement structures that enhance runoff.

Reductions in heat stress is important for small kids and the elderly persons. In a study in Bronx, it was predicted that 2% - 5% increases in tree cover had minimal impact on air temperature as well as decrease in heat index (Nyelele et al 2019). Scott et al (1999) reported air temperatures reduction by 1 to 3°F by trees in a Davis, CA parking lot. Tree cover increase from 22% to 31% in Bronx reduced air temperature by 0.1^0C, further increase in tree cover to 32% reduced it by 0.2^0C Rosenzweig et al. (2009). Basu and Ostro (2008) reported that with 10ºF increase in mean daily heat index, 2.6 % percent cardiovascular mortality is increased. In Bangalore city of India, survey showed that air temperature was 5.6 °C lesser in roads which were having trees on both side, and the temperature of the road surface was 27.5 °C less compared to the roads without trees (Vailshery et al 2013). Shade trees and grass in courtyard in Israel revealed decrease in air temperatures up to 2.5 °C Shashua-Bar et al (2010). Another study reports that temperature of wall is reduced by 9 °C and temperature of air up to 1 °C due to tree shade (Berry et al 2013). However, to generalize this is difficult as impacts will dependent on kind of materials, building design, tree geometry, and species, aspect and season. The impact of increase temperature in damaging to health however, majority population in urban areas across globe die due to cold weather conditions and not heat (Hajat et al 2014; Gasparrini et al 2015). Therefore, reduced ambient temperature during winter because of shade from trees growing in streets may have an adverse impact on health. Reduced levels of light due to presence of tree canopy during winter may have an impact on mental wellbeing for some individuals who are prone to Seasonal Affective Disorder (Kurlansik and Ibay 2012). Presence of tree shading around house also result in decreased indoor temperatures, which may increase mould, dampness and thus increase energy requirement for heating the building during winter. Grouping trees in to distances or small groups with ample open areas imitating 'savannah' arrangement (Spronken-Smith 1994) will reduce radiative load and permits long wave cooling during night. Orientation of trees is also an effective way for reducing energy consumption levels. Trees orienting in south and west direction of house result in reduces costs of cooling/heating the buildings (Donovan, and Butry 2009). Tree influence the health of public by improving air quality, encourages physical activity of humans, lowers stress levels and improve relationships among fellow dwellers (Hystad et al 2014).

Converting forest to agroforest or agriculture also impacts provisioning services. Conversion of forest to agriculture reduces annual and standing litter fall of 71% and 43% respectively in coffee monocrops. This reduction is 41 % and 29 % when forests are converted to coffee agroforest. This shows that we need to manage land uses that maintain litter inputs. The litter presence would conserve native earthworm that contribute to soil macroporosity and thus increase downward movement of water in soil and hence reduce soil erosion and runoff (Hairiah et al 2006).

The relationship between aboveground (vegetation/crops) and belowground biodiversity (soil organisms) emphasizes tree cover management which influences agricultural landuse though soil-based ecosystem services (De Bello et al 2010). Leeuw et al 2014 have enlisted role of agroforestry in providing regulating services (Table 3).

About 22,0000 out of an estimated 24,0000 plant species require a bee or humming bird to complete pollination. This includes wild plants and over 70% of the food species used to feed the world's population. This pollination services, which ensure the persistence of plants in our croplands, home gardens, rangelands, meadows, and forests, are known to be provided by over 100,000 distinct animal species, including bats, bees, beetles, birds, butterflies, and flies (Buchmann and Nabhan 1996). The pollination service is important as 35% of global crop production is dependent on insect pollination directly or indirectly (Klein et al 2007).

Table 3. Role of agroforestry in regulating ecosystems processes (Leeuw et al 2014).

Regulating Services	Livelihood Assets		
	Human	Natural	Financial
Microclimate	Improve productivity of drylands thus improves Health and Nutrition	Provide shade, reduce wind and raindrops velocity and momentum, reduce body energy loss from livestock	Indirect impact on income from other services.
Air quality	Health by reducing dust	Reduce dust and offer soil cover	Indirect impact on income from other services
Macroclimate	Improve productivity of drylands thus improves Health and Nutrition	Carbon sequestration	Indirect impact on income from other services
Flood + groundwater control	Improve productivity of drylands thus improves Health and Nutrition	Reduce runoff thus improve soil moisture and ground water recharge	Indirect impact on income from other services
Pest and disease control	Health of human and livestock	-	Indirect impact on income from other services

The conversion from forests to landuses having lesser tree canopy (agriculture, urban landscape, *etc*) significantly reduces species diversity, abundance and efficacy of insect pollinators. A study comparing richness of total insect pollinators in monocrop and forest revealed that the pollinators declined by 14% contrary to native forests. Whereas, in Mixed-tree (MT) agroforestry, 93% of crop pollinators were same as those in natural forest. Thus, agroforestry is recommended in the buffer zones around forest fragments for habitat management (Barrios et al 2012). A study had revealed that women living in adjacent to trees (< 50 metre radius) had less chances of giving birth to low weight children (Laurent et al 2013). Nevertheless, the trees providing ecosystem services may also be a precursor in damaging the infrastructure and cause allergies (Gómez-Baggethun et al 2013). A study in London showed that the antidepressant medicines were lesser in areas having higher density of trees (Taylor et al 2015). Another study in Netherlands showed positive influence of trees on the general and mental health of persons residing in vicinity of trees. Tree location affects its ecosystem functions and is important in reducing air pollutants (Cimburova and Barton 2020). Trees with large leaf area intercepts large volume of precipitation, provide more shadow, act as wind shelter and interact with a larger air space. Leaves are settling areas for particulate matter present in air (Kardell et al 2011). Thus, managing tree populations is necessary in cities and are thus advocated as a tool to address environmental issues (Nowak, 2006). Trees alongside roads and canal act as sink for pollutants; reduce urban O_3 levels; check partimulate matter, reduce noise pollution; reduce air temperature; and add aesthetic value to the urban landscape (Chavan and Rasal 2010; Nowak et al 2018). They also fix atmospheric C in their biomass for urban localities, modify microclimate, fix airborne pollutants and control storm water runoff (Srinidhi et al 2007).

Wolf (2007) and Chaudhury (2006) reported that presence of park and its facing and distance affect the valuation of property (Table 4; Wolf 2005, 2007; Chaudhury 2006)

Table 4. Proximate principle Property value hike Location of property

Property value hike	Location of property
10%	Within ¼ mile (0.4 km) of a park
20%	Near to or facing a park
32%	Within or close to green belts

C. Cultural services

The MEA (2005) defined Cultural ecosystem service vaguely as "nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences". Cultural ecosystem services (CES) have a special role because of their intangibility, emotional and mental benefits and partly non-consumptive character (Milcu et al., 2013). CES have to be measured with non-monetary methods in order to fix their poor quantification and integrate them into ESS frameworks (Szücs et al 2015). Cultural values of a region or ecosystem is important and needs protection as they are unique, irreplaceable and have importance in economic societies (Szücs et al 2015). The main objective of maintaining vegetation in parks and educational areas is to harness ecosystem services related to culture i.e. avenue, aesthetics, religion and recreation. These services are part of ecosystem services attuned to culture and in India plants have been worshipped since ancient time.

D. Supporting services

Ecosystems are unsustainable in the absence of underlying natural processes, like photosynthesis, nutrient cycling, soil formation, and water cycle. These processes enable Earth to carry forward basic life forms, along with whole ecosystems and people. In absence of supporting services, provisional, regulating, and cultural services wouldn't exist. The growing of trees in agricultural areas benefits the soil in a number of ways, both for crop growth and as a habitat for soil creatures. Trees alter the soil environment in a variety of ways: their leaves deflect rainfall, drain water that their roots have absorbed from ground, and shade crops and soil below the canopy; their clipped branches and leaves cover the soil and enrich it with nutrients. These processes alter the soil's temperature, moisture content, and susceptibility to erosion, nutrient content, and soil biota (Barrious et al 2012). In agroforestry systems, the major component of nutrient cycling is litter, which contains a significant quantity of the nutrients needed for plant growth (Zheng 2006).

Replacing cassava cultivation with young rubber plantations in Thailand shows that converting from annual crops to trees based landuse system contributes to higher diversity in the soil macrofauna community, results in higher earthworm ($p < 0.05$) leading to better soil health (Pauli et al 2011). Tree planted in parks and education/office areas in cities provides supporting as well as regulating services. They improve the urban environment through purification of air, temperature moderation, shade, provide habitat for fauna. These trees also absorbs/filters dust particles, and other forms of pollutants. Conserving soil, water and nutrient cycling and conservation of biodiversity are among other services which presence of tree provide. 31 plant species which was 41.33% of the total observed species were providing supporting and regulating during summers all the visitors in parks. Flowering species attracted honey bees and many other pollinators (Pradhan et al 2020).

Tree pollen allergies in Europe has been reported to range from around 5 % to over 50 % (D'Amato et al 2007) thus is a significant environmental health issue. In the city of Cordoba, Spain, 30 % of the total pollen count during winter is of Cupressaceae which is responsible for allergic rhinitis and it happens when no other allergenic plants are flowering (Alcázar et al 2004).

Difficulties in Ecosystem services valuation

The studies carried out on ecosystem services are sporadic and are focused on one or two parameters like soil nutrient, carbon sequestration, fodder, fuel and timber production. Most of the studies are focused on provisioning type of services. Cultural, regulating and supporting services are scanty. Ecosystem services have been presumed to be always positive, however, it might be positive for one parameter and negative for other. A study in sub-sahara Africa revels that extremes of + ve and –ve impact might be provided by presence of trees (Kuyah et al 2016) (Fig. 1).

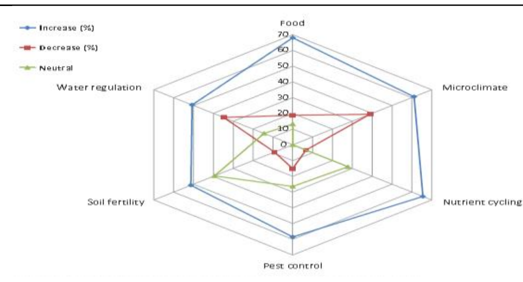

Figure 1. Proportions (%) of Ecosystem services that increase and decrease by trees in Sub-Saharan Africa (Adopted from Kuyah et al 2016)

Due to variable parameters, assessment of Ecosystem services is difficult. Several reports show that estimated values of ecosystem services significantly vary with ecosystem types, ES, valuation methods, and economic development (Costanza et al 2014; Teoh et al 2019). Estimated values of ES had showed variations and varied patterns. Large variations in the ES values in China are observed. Among different methods used, the market price methods, in combination with the avoided cost method and Contingent Valuation Method/Choice Experiment Method, showed better values than the rest of the five methods - Equivalent factor method, Shadow price method, Replacement cost method, and Travel cost method. These calculated values are sensitive to the type of valuation methods adopted (Kang et al 2021).

Combination of several types of valuation techniques had shown encouraging results (Jacobs et al 2018). For ES valuation, the use of different methods gives advantages for integrating different user groups and value types (Jacobs et al 2018) on one hand and also helps exploiting relation between top-down and bottom-up contexts. These system services are dependent upon kind of species and age of tree, area, seasonality of the leafy canopy and thus their valuation is ever varying and requires continued assessment.

References

Alcázar P, Cariñanos P, De Castro C, Guerra F, Moreno C and Domínguez-Vilches E 2004. Airborne plane-tree (*Platanus hispanica*) pollen distribution in the city of Córdoba, South-western Spain, and possible implications on pollen allergy. *J Investig Allergol Clin Immunol* **14**(3): 238–243.

Barrious E, Sileshi GW, Shephard KD and Sinclair F 2012. Agroforestry and Soil Health: Linking Trees, Soil Biota, and Ecosystem Services. *Soil Ecology and Ecosystem Services*, *Oxford University Press.* **1**: (5.2).

Basu R and Ostro BD 2008. A Multicounty Analysis Identifying the Populations Vulnerable to Mortality Associated with High Ambient Temperature in California. *American Journal of Epidemiology* **168**: 632–637.

Berry R, Livesley S J and Aye L 2013. Tree canopy shade impacts on solar irradiance received by building walls and their surface temperature. *Build Environ* **69**:91–100.

Biggs R, Schlüter M and Schoon ML 2015. Principles for building resilience: sustaining ecosystem services in social-ecological systems. *Cambridge University Press.*

Blanckaert I, Swennen RL, Paredes-Flores M, Lopez RR and Saade RL 2004. Floristic composition, plant uses and management practices in homegardens of San Rafael Coxcatlán, Valley of Tehuacán-Cuicatlán, Mexico. *Journal of Arid Environment* **57**: 39-62.

Blanckaert I, Swennen RL, Paredes-Flores M, Lopez RR and Saade RL 2004. Floristic composition, plant uses and management practices in homegardens of San Rafael Coxcatlán, Valley of Tehuacán-Cuicatlán, Mexico. *Journal of Arid Environment* **57**: 39-62

Buchmann SL and Nabhan GP 1996. The pollination crisis: the plight of the 334 honey bee and the decline of other pollinators imperils future harvests. *Science* **36**: 22.

Caballero-Serrano V, Onaindia M, Alday JG, Caballero D, Carrasco JC and McLaren B 2016. Plant diversity and ecosystem services in Amazonian homegardens of Ecuador. *Agric Ecosyst Environ* **225**: 116–25.

Caballero-Serrano V, Onaindia M, Alday JG, Caballero D, Carrasco JC and McLaren B 2016. Plant diversity and ecosystem services in Amazonian homegardens of Ecuador. *Agric Ecosyst Environ* **225**: 116–25

Charity N, Kroll CN and Nowak DJ 2019. Present and future ecosystem services of trees in the bronx, NY. *Urban Forestry & Urban Greening* 42: 10-20.

Chaudhury P 2006. Valuing recreational benefits of urban forestry – a case study Chandigarh city. *Ph.D. Thesis*, FRI (Deemed University), Dehra Dun, India

Chavan BL and Rasal GB 2010. Sequestered standing carbon stock in selective tree species grown in University campus at Aurangabad, Maharashtra, *India. Int J Eng Sci Tech* **2**: 3003–3007.

Cimburova Z and Barton DN 2020**.** The potential of geospatial analysis and Bayesian networks to enable i-Tree Eco assessment of existing tree inventories. *Urban For. Urban Green* **55:** (126801)

Clarke LW, Li L, Jenereeta GD and Yu Z 2014. Drivers of plant biodiversity and ecosystem service production in home gardens across the Beijing Municipality of China. *Urban Ecosyst* **17**: 741-760.

Costanza R, de Groot R, Sutton P, van der Ploeg S, Anderson SJ and Kubiszewski I 2014. Changes in the global value of ecosystem services. *Glob. Environ. Chang. Hum. Policy Dimens* **26**: 152–158.

Crowther TW, Glick HB, Covey KR, Bettigole C, Maynard DS, Thomas SM, Smith JR, Hintler G, Duguid MC, Amatulli G, Tuanmu MN, Jetz W, Salas C, Stam C, Piotto D, Tavani R, Green S, Bruce G, Williams SJ, Wiser SK, Huber MO, Hengeveld GM, Nabuurs GJ, Tikhonova E, Borchardt P, Li CF, Powrie LW, Fischer M, Hemp A, Homeier J, Cho P, Vibrans AC, Umunay PM, Piao SL, Rowe CW, Ashton MS, Crane PR and Bradford MA 2015. Mapping tree density at a global scale. *Nature*. Sep 10 **525**(7568): 201-5.

Daily GC 1997. Introduction: what are ecosystem services? In: Daily, 605 G.C. (Ed), Natures 606 services: societal dependence on natural ecosystems. Island Press, Washington, DC, 1-10.

D'Amato G, Cecchi L, Bonini S, Nunes C, Annesi-Maesano I, Behrendt H 2007. Allergenic pollen and pollen allergy in Europe. *Allergy* **62**(9): 976–90.

Das T and Das AK 2005. Inventorying plant biodiversity in homegarden: a case study in Barak valley, Assam, north east India. *Curr Sci* **98**: 155-163

Davey Resource Group 2014. Phoenix, Arizona - Project Area Community Forest Assessment. Retrieved September 23rd, 2017. https://www.itreetools.org/resources/reports/DesertCanopy/Phoenix_Community_Forest_Assessment_1.2.15-Final.pdf.

De Bello F, Lavorel S, Díaz S, Harrington R, Cornelissen JHC, Bardgett RD, Berg MP, Cipriotti P, Feld CK and Hering D 2010. Towards an assessment of multiple ecosystem processes and services via functional traits. *Biodiv Conserv*. **19**: 2873–2893.

Donovan GH and Butry DT 2009. The value of shade: Estimating the effect of urban trees on summertime electricity use. *Energy Build* **41**: 662–668.

Ehrlich PR and Mooney HA 1983. Extinction, substitution, and ecosystem services. *Bioscience* **33**: 248–254.

Farber S, Costanza R, Childers DL, Erickson J, Gross K, Grove M, Hopkinson CS, Kahn J, Pincetl S, Troy A, Warren P and Wilson M 2006. Linking ecology and economics for ecosystem management**.** *BioScience*, **56**(2): 121-133.

Feng Z, Cui Y, Zhang H and Gao Y 2018. Assessment of human consumption of ecosystem services in China from 2000 to 2014 based on an ecosystem service footprint model. *Ecol. Indic.* **94**: 468–481.

Foley JA, Defries R, Asner GP, Barford C, Bonan G, Carpenter SR, Chapin FS, Coe MT, Daily GC, Gibbs HK, Helkowski JH, Holloway T, Howard EA, Kucharik CJ, Monfreda C, Patz JA, Prentice IC, Ramankutty N and Snyder PK 2005. Global consequences of land use. *Science* **309**: 570–574. http://dx.doi.org/10.1126/science. 1111772.

Gasparrini A, Guo Y, Hashizume M, Lavigne E, Zanobetti A and Schwartz J 2015.Mortality risk attributable to high and low ambient temperature: a multicountry observational study. *Lancet* **386**(991): 369–75

Gibbs HK, Ruesch AS, Achard F, Clayton MK, Holmgren P, Ramankutty N and Foley JA 2010. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *Proc. Natl. Acad. Sci*. **107**: 16732–16737. http://dx.doi.org/10.1073/pnas. 0910275107.

Gómez-Baggethun E, Gren Å, Barton DN, Langemeyer J, McPhearson T, O'Farrell P, Andersson E, amstead Z and Kremer P 2013. Urban Ecosystem Services. In Urbanization, Biodiversity and Ecosystem Services: challenges and Opportunities: A Globle Assessment; *Springer: Dordrecht, The Netherlands* 175–251.

Goodman RC and Herold M 2014. Why maintaining tropical forests is essential and urgent for a stable climate. *Cent. Glob. Dev. Work. Pap*.

Hairiah K, Sulistyani H, Suprayogo D, Widianto, Purnomosidhi P, Widodo RH, Van and Noordwijk M. 2006. Litter layer residence time in forest and coffee agroforestry systems in Sumberjaya, West Lampung. *Forest Ecol Mgmt* **224**: 45–57.

Hajat S, Vardoulakis S, Heaviside C and Eggen B 2014. Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s, and 2080s. *J Epidemiol Community Health* **68**: 641–8.

https://doi.org/10.1016/j.scitotenv.2018.08.422

https://doi.org/10.1073/pnas.1502452113

Hystad P, Davies HW, Frank L, Van Loon J, Gehring U, Tamburic L and Brauer M 2014**.** Residential Greenness and Birth Outcomes: Evaluating the Influence of Spatially Correlated Built-Environment Factors. *Environ. Health Perspect* **122**: 1095–1102.

Jacobs S, Martin-lopez B, Barton DN, Dunford R, Harrison PA, Kelemen E, Saarikoski H, Termansen M, Garcia-llorente M, Gomez-Baggethun E, Kopperoinen L, Luque S, Palomo I, Priess JA, Rusch GM, Tenerelli P, Turkelboom F, Demeyer R, Hauck J, Keune H and Smith R, 2018. The means determine the end – pursuing integrated valuation in practice. *Ecosyst. Serv*. **29**: 515–528.

Kang N, Hou L, Huang J, Liu H, 2021. Ecosystem services valuation in China: A meta-analysis. *Sci. Total Environ* **809**:151122.

Kardel F, Wuyts K, Maher, BA, Hansard R, and Samson R 2011. Leaf saturation isothermal remanent magnetization (SIRM) as a proxy for particulate matter monitoring: inter-species differences and in-season variation. *Atmospheric Environment* **45**(29): 5164-5171.

Kissinger G and Herold M 2012. Drivers of deforestation and forest degradation. *A Synth. Rep. REDD+ Policymakers*.

Klein AM, Vaissiere BE, Cane JH, Steffan-Dewenter I, Cunningham SA, Kremen C and Tscharntke T 2007 Importance of pollinators in changing landscapes for world crops. *Proc R Soc B* **274**: 303–313.

Kumari MAS, Kansuntisukmongkol K and Brockelman WY 2009. Plant diversity in Homegardens and its contribution to household economy in suburban areas in Sri Lanka. *Environ Nat Resour J* **7**: 12-30.

Kurlansik SL and Ibay AD 2012. Seasonal affective disorder. *Am Fam Physician* **86**(11): 1037–41.

Kuyah S, Ö Ingrid, Jonsson M, Dahlin A S, Barrios E, Muthuri C, Malmer A, Nyaga J, Magaju C, Namirembe S, Nyberg Y and Sinclair FL 2016 Trees in agricultural landscapes enhance provision of ecosystem services in Sub-Saharan Africa, *International Journal of Biodiversity Science, Ecosystem Services &Management***12**:4255-273.

Laurent O, Wu J, Li L and Milesi C 2013. Green spaces and pregnancy outcomes in Southern California. *Health Place* **24:**190–195.

Leeuw JD, Njenga M, Wagner and Iiyama M 2014. Treesilience: An assessment of the resilience provided by trees in the drylands of Eastern Africa. *World Agroforestry Centre*, Nairobi, Kenya

Lefcheck JS, Byrnes JEK, Isbell F, Gamfeldt L, Griffin JN, Eisenhauer N, Hensel MJS, Hector A, Cardinale BJ and Duffy JE 2015. Biodiversity enhances ecosystem multifunctionality across trophic levels and habitats. *Nat. Commun* **6**: 6936.

Li X, Yu X, Hou X, Liu Y, Li H, Zhou Y, Xia S, Liu Y, Duan H, Wang Y and Dou Y 2020. Valuation of wetland ecosystem services in national nature reserves in China's Coastal Zones. *Sustainability* **12**(8): 3131.

Ma X, Zhu J, Zhang H, Yan W and Zhao C 2020. Trade-offs and synergies in ecosystem service values of inland lake wetlands in Central Asia under land use/cover change: a case study on Ebinur Lake, China. *Glob. Ecol. Conserv,* **24**: 01253.

MEA, Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-Being: Our Human Planet: Summary for Decision Makers. *The Millennium Ecosystem Assessment Series* Island Press, Washington DC **5**.

Mekonnen EL, Asfaw Z and Zewudie S 2014. Plant species diversity of homegarden agroforestry in Jabithenan district, North-wertern, Ethiopia. *Int J Biodiversity Conserv* **6(**4): 301-307.

Milcu AI, Hanspach J, Abson D and Fischer J 2013. Cultural Ecosystem Services. A Literature Review and Prospects for Future Research. *Ecol Soc* **18**(3): 44.

MillionTrees NYC, 2017. About MillionTrees NYC. Retrieved June 17th, 2017 from 662 http://www.milliontreesnyc.org/.

Nowak DJ 2006. Institutionalizing urban forestry as a ‘biotechnology’ to improve environmental quality. *Urban Forestry and Urban Greening,* **5**: 93-100.

Nowak DJ, Hirabayashib S, Doylec M, McGovernc M and Pasher J 2018. Air pollution removal by urban forests in Canada and its effect on air quality and human health. *Urban For Urban Green* **29**: 40–48.

Palomo I, Felipe-Lucia M.R, Bennett EM., Martín-López B, Pascual U 2016. Chapter six-disentangling the pathways and effects of ecosystem service co-production. *Adv. Ecol. Res*. **54**: 245–283.

Pauli N, Barrios E, Conacher AJ and Oberthur T 2011. Soil macrofauna in agricultural landscapes dominated by the Quesungual Slash-and-Mulch Agroforestry System, western Honduras. *Appl Soil Ecol* **47**: 119–132.

Posner SM, McKenzie E, Ricketts TH 2016. Policy impacts of ecosystem services knowledge. *Proc. Natl. Acad. Sci* **113**: 1760–1765.

Pradhan R, Abha MK, Vineeta, Sarkar BC, Bhat JA, Shukla G, Chakravarty S 2020. Ecosystem services of urban green sites- A case study from Eastern Himalayan foothills. *Trees, Forests and People* **2**: 100029.

Reed James , Vianen JV, Foli S, Clendenning J, Yang K, MacDonald M, Petrokofsky G, Padocha C and Sunderland T 2017. Trees for life: The ecosystem service contribution of trees to food production and livelihoods in the tropics. *Forest Policy and Economics* **84**: 62–71.

Rodríguez-Robayo KJ, Perevochtchikova M, ´Avila-Foucat S and De la Mora G 2020. Influence of local context variables on the outcomes of payments for ecosystem services. Evidence from San Antonio del Barrio, Oaxaca, Mexico. *Environ. Dev. Sustain.* **22**: 2839–2860.

Rosenzweig C, Solecki WD, Parshall L, Lynn B, Cox J, Goldberg R, Hodges S, Gaffin S, Slosberg RB, Savio P, Dunstan F and Watson M, 2009. Mitigating New York City’s Heat Island: Integrating Stakeholder Perspectives and Scientific Evaluation. *Bulletin of the American Meteorological* Society **90**:1297–1312.

Roy B, Mohammad HR and Fardusi MJ 2013. Status, Diversity, and Traditional Uses of Homestead Gardens in Northern Bangladesh: A Means of Sustainable Biodiversity Conservation,*SRN Biodiversity*1-11.

Schadegan FH, Khoshbakht K, Damghani AM, Veisi H, Liaghat H, Kambouzia J 2013. A Multidisciplinary Study of Rural Homegardensin Basht, Southwestern Iran. *Middle-East Journal of Scientific Research* **13**:1431-1437.

Scott KI, Simpson, JR and McPherson E.G 1999. Effects of tree cover on parking lot microclimate and vehicle emissions. *Journal of Arboriculture* **25**(3):129-142.

Shashua-Bar L, Pearlmutter D, Erell E 2010. The influence of trees and grass on outdoor thermal comfort in a hot-arid environment. *Int. J. Climatol* **31**:1498-1506.

Smith P, Bustamante M., Ahammad H, Clark H, Dong H, Elsiddig EA, Haberl H, Harper R, House J and Jafari M 2014. Agriculture, forestry and other land use (AFOLU). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the *Fifth Assessment Report*.

Spronken-Smith RA 1994. Energetics and cooling in urban parks. PhD thesis. *University of British Columbia. Geography Department*.

Srinidhi HV, Datta SK, Chauhan R and Gill MK 2007. Dendroremediation: use of trees to cleanup environment in different land use systems. *Environ Ecol* **25**:245–254.

Subba M, Pala NA and Shukla G 2018 Study of the variability of homegardens influencing carbon stock under sub-humid tropical zone of West Bengal, India. *Indian For* **144**: 60-66.

Szücs L, Anders U and Bürger-Arndt R 2015. Assessment and illustration of cultural ecosystem services at the local scale. Aretrospective trend analysis. *EcolIndic* **50**:120–134. http://doi.org/10.1016/j.ecolind.2014.09.015

Taylor MS, Wheeler BW, White MP, Economou T, Osborne NJ 2015**.** Research note: Urban street tree density and antidepressant prescription rates—A cross-sectional study in London, UK. *Landsc. Urban Plan*. **136**: 174–179.

Teoh SHS, Symes WS, Sun H, Pienkowski T and Carrasco LR 2019. A global meta-analysis of the economic values of provisioning and cultural ecosystem services. *Sci. Total Environ* **649**:1293–1298.

Vailshery LS, Jaganmohan M and Nagendra H. 2013. Effect of street trees on microclimate and air pollution in a tropical city. Urban Forestry Urban Greening.**12(**3):408–15. doi:10.1016/j.ufug.2013.03.002.
Vargas KE, McPherson GE, Simpson JR, Peper PJ, Gardner SL and Xiao Q 2008. Tropical community tree guide: benefits, costs, and strategic planting. Gen. Tech. Rep. PSW-GTR-216. Albany, California: US Department of Agriculture, Forest Service, Pacific Southwest Research Station. 109, 216.
Vogl-Lukasser B and Vogl C 2004. Ethnobotanical research in home gardens of small farmers in the alpine region of Osttirol (Austria): an example for bridges built and building bridges. *Ethnobot Res Appl* **2**:111–137.
Westman WE 1977. How much are nature's services worth. *Science* **197**(80):960–964. http://dx.doi.org/10.1126/science.197.4307.960.
WHO, 12–14 March 2018. *Ethical, Legal, Human Rights and Social Accountability Implications of Self-care Interventions for Sexual and Reproductive Health*., Brocher Foundation, Hermance, Switzerland.https://apps.who.int/iris/bitstream/handle/10665/273989/WHO-F W C-18.30-eng.pdf
Wolf KL 2005. Business district streetscapes, trees and consumer response. *J For* **103**:396–400.
Wolf KL 2007. City trees and property values. *Arborist News*, August 2007.
Wondie A 2018. Ecological conditions and ecosystem services of wetlands in the Lake Tana Area, Ethiopia. *Ecohydrol. Hydrobiol,* **18**(2):231–244.
Wunder S 2008. Payments for environmental services and the poor: concepts and preliminary evidence. *Environ. Dev. Econ.* **13**:279–297.
Zheng Z 2006. Litter decomposition and nutrient release in a tropical seasonal rain forest of Xishuangbanna, Southwest China. *Biotropica* **38**(3): 342–347.

1.4/Lead Paper

Precision Tree Farming for Economic and Environmental Sustainability

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Need of Precision Tree farming

Wood products have always been in demand despite the availability of several substitutes such as iron, steel, and aluminium, etc., and increases in the price of wood. This may be explained by the high degree of social acceptance of wood in India and its accessibility, even in isolated areas. Although India's forest and tree cover has been steadily increasing for nearly two decades, India still remains deficient in timber production and an increasingly large proportion of its burgeoning demand is being met from outside sources. The total annual wood demand of the country is estimated to be 600 M cu.m of which total round wood demand in India is estimated to be 199 M cu.m., where Teak accounts almost half of the total round wood requirement (95 M cu.m) which arises mainly from the construction sector, furniture industry, pulp and paper industry, and handicraft industry. The Indian timber market is very dependent on supplies from four main sources, i.e., harvest carried out by the state forest departments, forest development corporations, areas under the control of private tree growers collectively known as Trees outside Forests (TOF), and imports.

The most demanded timber species of India includes, Teak, Sandal, Sheesham, Deodar, Ebony, Rosewood, Red sanders, and Sal. Teak accounts for almost 50% of the total wood-based industries produced, sal and deodar account for about 20% and the balance includes mahogany, cedar and other tree species. India alone consumes 70 to 100 per cent of Teak logs from Africa and Latin America and 90,000 cu.m of Teak is imported annually. In addition to the forest policy guide lines, resulting scarcity of fuel wood, timber for construction and wood for a huge array of industrial and commercial uses has imposed to promote commercial tree plantations outside the forest areas to meet the demand. The scenario necessitates the increased supply of output within shorter time period by reducing the rotation age of the tree crop by adopting modern tree farming technologies. This can be achieved by adoption of précised silvicultural technologies in tree farming impacting higher productivity in tree crops without compromising quality.

Concept of precision tree farming

Precision silviculture uses advanced systems of tree farming dealing with site-specific management of trees. In order to increase the yield under short rotation period, Forest College and Research Institute developed precision tree farming techniques for an array of tree crops. The results are demonstrated in the institute and technologies are provided for farmers/tree growers and the technologies were transferred to farmer's field across the state.

Precision Teak Farming Techniques

Forest College and Research Institute has developed Precision Tree farming techniques for Teak based on the experiments conducted on Teak for the past three years. The technology is being transferred to farmer's field for 69 acres across different agro climatic regions of Tamil Nadu. The component of the technology is furnished below:

Components of Technology	Silvicultural techniques
Quality Planting Material	Seedlings from identified genetic resources
Land Preparation Techniques	Land cleaning followed by disc ploughing and fine tilth ploughing
Spacing	10 ft. x 10 ft.
Pitting	1.5 ft x 1.5 ft x 1.5ft

Basal dose of FYM and Biofertilizers	FYM 3 kg/pit and Biofertilizer mix 250 g/pit
Planting Technique	Mixing of FYM and Biofertilizer mix with top soil of the pit. This soil and manure mix will be placed near the root zone of the seedlings followed by the soil from the bottom layer of the pit.
Irrigation	Drip irrigation • 5 to 8 liters/day/plant upto one year • 7 to 10 litres/day/plant upto two year • 15 to 20 liters/day/plant after two years (upto 8 years) (Irrigation recommended only during lean season)
Fertilizer application	Recommended Doze of Fertilizer 1. RFL - 150:100:100 kg/ha (Up to two years in three split applications) 2. RFL - 300:200:200 kg/ha (After two years upto eight years in three split applications)
Singling	Multiple stems can be removed by leaving dominant single leading stem having superior apical dominance.
Weeding	Mechanical weeding with inter ploughing by tractor or rotavator.
Bud pruning	Pruning of young side branches at the stage of one bud with two leaves. Bud pruning can be done upto 10 feet.
Leaf management during young stage	Leaves are allowed to grow upto natural fall (Senescence). Live leaves are not recommended for pruning
Pruning	Pruning of branches with tree pruner when the plant reached the height above two feet. The branches at the growth stage of pencil thickness should be pruned. Pruning of branches should be carried out upto 20 -25 feet from the base of the main bole in order to ensure knot free clean bole growth.
Thinning	Selective thinning can be carried out based on canopy closer stage. Suppressed trees will be culled and the superior dominant trees will be allowed. Selective thinning is recommended from third after planting. However, it may vary depends on site productivity.
Pest and diseases	Pests: Root grub, Defoliator, Skeletonizer, Mealy bug, stem borer Diseases: Collar rot, Root rot and Powdery mildew.
Stressing	Irrigation and fertilizer application is recommended upto 130 to 150 cm GBH. Then, the trees should be allowed for stressing by gradually reducing the fertigation.
Yield	Farmers realized yield is 1 to 1.5 CFT per year based on site quality. Thus in 15 years rotation the expected yield is 15 to 20 CFT per tree. Tree population at final harvest is 200 per acre.

Model precision teak experimental trials established by FCRI, Mettupalayam

1. Genetic improvement of Teak

The research trial was established in order to test for the best source for multiplication of Teak for sustainable wood production. The field study comprising teak planting stock from different sources were established at Forest College & Research Institute, Mettupalayam, Coimbatore district of Tamil Nadu, India (11º32” N and 76º93” E).

The details of the sources are given below.

Treatment	Source	Genetic source
1	Assam	Lanka
2	Gujarat	Baroda
3	Andhra Pradesh	Visakhapatnam
4	Karnataka	Shivamoga
5	Kerala	Nilambur
6	Tamil Nadu	Topslip
7	Odisha	Bhavanipatna
8	Odisha	Hakimpada
9	Odisha	Baripada

The biometric observations were taken on monthly basis after the establishment of the trial. The growth biometry was taken as a function of height and diameter increment. The trial performs well comparing with the native genotype. At initial stages, Gujarat source showed maximum increment in diameter (23.50 cm) and the performance of Assam source (19.60) was poor compared to other source, while at 18 months after planting the Assam source (29.20 cm) showed maximum diameter increment followed by Tamil Nadu (26.80 cm).

With respect to the height increment at initial stage the native Tamil Nadu source registered maximum increment, while at 12 months after planting Andhra Pradesh (4.27m) showed maximum height increment while at 18 months after planting, south varieties Andhra Pradesh, Kerala, Karnataka and Tamil Nadu performs with maximum height increment. The research concluded that the effect of the genotypic nature of the propagules can be manipulated for the selection of best quality planting material for sustainable teak production.

Plate 1. Teak Provenance Research Trial at FC&RI, Mettupalayam

Fertigation for studies in teak

The field experiment was carried out in four months old teak plantation raised at farmer's field in Pachapalayam near Perur at Coimbatore district to standardize the irrigation and fertilizer requirements of teak (*Tectona grandis* Linn.f) under drip irrigation system during its early growth phase. Irrigation is scheduled based on computed water requirement of tree based on crop factor, daily rainfall and evapotranspiration and fertlizer as per the reference fertilizer dosage of 150:100:100 NPK/ha. The drip irrigation system was installed in the field with the view of optimizing the water and nutrient scheduling in the teak plantation under three-year-old plantation. The details of the treatment layout is given below-

Location	Pachapalayam, Perur, Coimbatore	Treatment details	
Farmer's name	Govindaraj (Renga estates)	Irrigation schedule	Fertilizer schedule
D.O.P	11.08.2020	I_1 – 50% PE	F_1 – 75% RFL
Spacing	3 X 3m	I_2 – 75% PE	F_2 – 100% RFL
Design of the experiment	Split plot design (3 replications)	I_3 – 100% PE I_4 – 125% PE	F_3 - 125% RFL F_4 - 150% RFL
Total area	7.5 acres		

The conventional method of irrigation (surface application) and fertilization (soil application) was kept as control. The experiment was laid out by the following split plot design with three replications. Observations are taken for growth biometry, soil nutrient status, leaf nutrient uptake and biochemical changes. In the study, the maximum values of biometry (Table 1) of the teak plantation were registered in the fertigation treatment F_3 (125 % RFL) which is on par with F_4 (150 % RFL). Conjoint application level of I_4F_3 i.e., irrigation and fertigation at 125% PE and fertigation at 125 % RFL respectively was observed to be the best combined treatments for the promotion of teak biomass and productivity. Hence, it is sufficient for the growth and development of teak during its early growth stages.

Plate 2. Four months old Teak field at Pachapalyam, Perur

Table 1. Effect of fertigation on growth biometry of Teak at 18 months after treatment (18 MAT)

Main Plot	Subplot	Height (m)	Basal Diameter (cm)	Volume index (cm^3)
I_1	F_1	3.52^{f}	11.0^{a}	4215.91^{a}
	F_2	3.46^{ef}	11.3^{a}	4340.66^{a}
	F_3	3.66^{f}	11.4^{a}	4675.39^{a}
	F_4	3.48^{ef}	11.1^{a}	4240.94^{a}
I_2	F_1	3.28^{def}	11.7^{a}	4456.64^{a}
	F_2	3.94^{f}	12.0^{a}	5639.50^{a}
	F_3	4.16^{abc}	12.1^{a}	6037.35^{a}
	F_4	4.01^{bcd}	11.8^{a}	5553.99^{a}
I_3	F_1	3.70^{de}	12.2^{a}	5383.29^{a}
	F_2	4.09^{bc}	13.1^{a}	6933.99^{a}
	F_3	4.29^{ab}	12.6^{a}	6769.55^{a}
	F_4	4.14^{abc}	12.8^{a}	6666.15^{a}
I_4	F_1	4.07^{bc}	12.8^{a}	6562.33^{a}
	F_2	4.21^{abc}	12.9^{a}	6940.31^{a}
	F_3	4.43^{a}	12.7^{a}	7072.59^{a}
	F_4	4.29^{ab}	12.8^{a}	6910.28^{a}
Grand mean		3.92	12.2	5774.93
SE(d)		0.153	0.443	493.0
CD		0.422	0.906	1335.8

The nitrogen, phosphorus and potassium dynamics under drip fertigation system is analysed by means of SURFER software and is presented figures 1 to 3.

Plate 3. Eleven months old teak trial in farmer fiels, Bavani

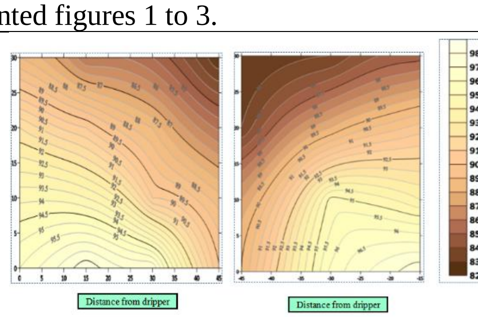

Figure 1 shown left is nitrogen distribution (Kg ha^{-1}) in 100 % RFL under drip fertigation

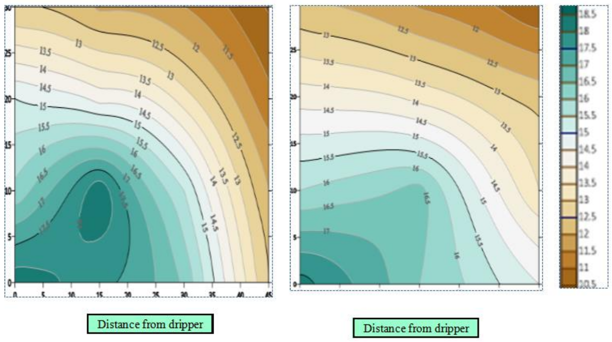

Fig. 2. Phosphorus distribution (Kg ha^{-1}) in 100 % RFL under drip fertigation

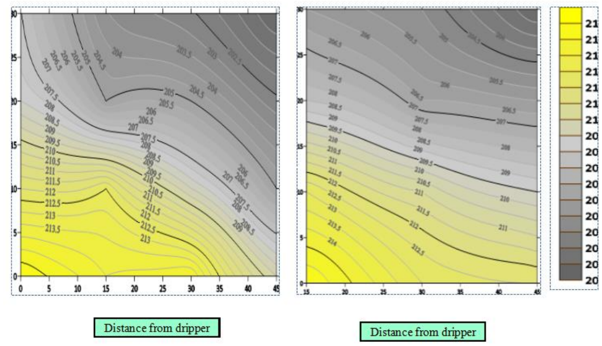

Fig. 3. Potassium distribution (Kg ha^{-1}) in 100 % RFL under drip fertigation

Genetic source with fertigation experiment

A field study was established on teak under fertigation treatment to study the genotype and fertigation interaction in teak at Forest College & Research Institute, Mettupalayam, Coimbatore district of Tamil Nadu, India (11°32" N and 76°93" E). The teak sources are collected from Assam, Gujarat, Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Orissa were tested with different sources of fertilizer and irrigation in the established field research trial. Fertilizers treatments were imposed through pre-installed drip irrigation systems by considering the Reference Fertilizer Level (RFL) for Teak in Indian condition as 150:100:100 kg/ha as recommended by Balagopalan, 2006. The details of the treatment are given below.

Teak Sources	Treatment details	
	Irrigation Schedule	Fertilizer Schedule
1) Topslip (Tamil Nadu)		
2) Nilambur (Kerala)	I_1-100% PE	F_1-125% RFL
3) Shivamoga (Karnataka)	I_2-75% PE	F_2-100% RFL
4) Visakapattanam (Andhra Pradesh)	I_3-50% PE	F_{3-}75% RFL
5) Baroda (Gujarat)	Design: FRBD	Replication: 3
6) Lanka (Assam)		
7) Bhavanipatna (Odisha)	D/P: 07-07-2020	Spacing 3m×3m
8) Hakimpada (Odisha)		
9) Baripada (Odisha)		

The outcome of the combined effect of fertigation with improved genotype is admiring and significantly higher than other treatments. The combined effect of 125 % RFL and 100 % PE, with the Assam source (29.20 cm) showed the greatest increase in diameter, with 125 % RFL and 100 % PE followed by Tamil Nadu and Gujarat source. In terms of height increment, south varieties Andhra Pradesh (8.25 m), Kerala (8.17 m), Karnataka (7.95 m), and Tamil Nadu (7.92 m) show the significant growth with 150 % RFL and 100 % PE. The research findings concluded that the combined effect of the provenance as well as the fertigation treatment can be manipulated for the selected of best quality planting material for sustainable teak production.

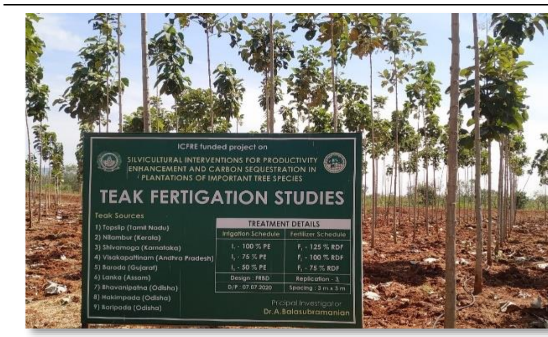

Plate 4. Teak fertigation Research Trial at FC&RI, Mettupalayam

Study on compatibility of black pepper (Piper nigrum, L) intercropped with Teak

Cultivating black pepper (*Piper nigrum*, L) is earlier recognised as possible only in hilly areas, but now a days pepper thrives wells in plains as an intercrop between trees. Pepper vines climb on teak, mahogany, Ailanthus etc. It will be very helpful for the pepper growers to look at the extra annual income even before they start getting the income from the timber trees after 5 to 10 years later. A field study was established at Forest College & Research Institute, Mettupalayam, Coimbatore district of Tamil Nadu, India (11º32" N and 76º93" E) to study the compatibility of Black pepper (*Piper nigrum,* L) under Teak fertigation system.

Plate 5. Black pepper intercropped with Teak

Plate 6. Black pepper intercropped with Teak at farmers field at Cuddalore

Intercropping Pepper under Teak	Irrigation Schedule	Fertilizer Schedule
With fertigation	Main Plot	Sub Plot
	I_1-100% PE	F_1-125% RFL
	I_2- 75% PE	F_2-100% RFL
	I_3-50% PE	F_3-75% RFL
Without fertigation	Control =Conventional method of application	

Design : FRBD, Replication : Three
Panniyur-1 : Hybrid- F_1 of Uthirankotta × Cheriyakaniyakadan

After 3 months of the experimental trial, the observed survival percentage of pepper intercropped between teak trees is 79%.

Precision tree farming technology for Indian Sandalwood (*Santalum album* L.)

Indian Sandalwood (*Santalum album* L.) may be considered as one of the world's most valuable commercial timber and is currently valued globally for its heartwood and oil. Sandal being a hemi parasite and requires different types of silvicultural management techniques in order to ensure good survival and establishment. Forest College and Research Institute has developed precision farming technology for sandal and being transferred to farmer's field. Sandal host association, host management, pruning, etc. were studied both at the research trials in FC&RI, MTP and also trials in farmers' field. The salient features of the technology are furnished below:

Components of technology	Particulars
Quality planting material	Seedlings from identified genetic resources
Land preparation techniques	Land cleaning followed by disc ploughing and fine tilth ploughing
Spacing	10ft. x 10ft.
Pitting	1.5ft.x 1.5ft. x 1.5ft.
Basal doze of FYM & Biofertilizers	FYM 3 kg/pit and Biofertilizer mix 250 g/pit
Planting technique	Mixing of FYM and Biofertilizer mix with top soil of the pit. This soil and manure mix will be placed near the root zone of the seedlings followed by the soil from the bottom layer of the pits
Relay host	• Nursery host - *Alternanthera sessilis* • Transits host in field - *Sesbania grandiflora* + *Gajanus gajan* • Permanent host - *Casuarina equisetifolia*
Bush Keeping	Sandal seedlings will be planted at the center of the pit along with primary host *Alternanthera sessilis*. Transit host • East west direction -*Sesbania grandiflora* • South North - *Gajanus gajan* Permanent host - *Casuarina equisetifolia* should be planted with in one foot from sandal.
Host Pruning Management	Initial growth upto breast height the host plants have to be grown. The all host plants should be toppled at breast height.
Irrigation	Drip irrigation (Irrigation recommended on need)
Weeding	Weeding is not recommended as sandal has the capacity to parasite with the weeds also. However at any point of time the height of the weed should not dominate the sandal seedlings.
Progressive Pruning	Sandal is highly sensitive to any kind of injury; hence, pruning should be done very minimally from the base. Hence, progressive pruning is recommended.
Pest and Diseases	Pests: Stem borer Diseases: Root rot
Stressing	Irrigation is recommended upto five years. Then the trees should be allowed for stressing by gradually reducing the irrigation.

Plate 7. Triple Host technology for sandal cultivation

Plate 8. Six months old sandal experiment in farmer field, Salem

Growth, yield assessment and carbon sequestration of farm grown trees in Tamil Nadu

Field surveys were conducted by FC&RI, Mettupalayam across different agroclimatic zones of Tamil Nadu *viz.,* North Eastern zone, North Western Zone, Cauvery Delta Zone, Western zone and Southern zone in order to study the edapho-climatic influence on farm grown Teak (*Tectona grandis,* Linn.f), Sandal (*Santalum album*) and Red Sanders (*Pterocarpus santalinus*).

The salient observations of the study is given below,

Edapho-climatic influence on growth and wood quality Teak

A field survey was conducted across different agroclimatic zones of Tamil Nadu in order to assess the edapho-climatic influence on growth and wood quality of farm grown Teak. The growth and yield were estimated under different age class viz., 5-10 years, 10-15 years and 15-20 years. The study concluded maximum growth biometry and wood quality in teak grown under North Western Zone of Tamil Nadu for block plantations and North Eastern Zone of Tamil Nadu for boundary plantations.

5-10 years age class

15-20 years age class

Red sanders

A field survey was conducted across different agroclimatic zones of Tamil Nadu in order to assess the edapho-climatic influence on growth and wood quality of farm grown Red Sanders. The growth and yield was estimated under different age class viz., 0-5 years, 5-10 years and 10-15 years. The study concluded maximum yield under North Eastern zone of Tamil Nadu followed by Cauvery Delta Zone and Southern Zone. North Eastern zone (NEZ) showed maximum heartwood proportion and growth biometrics of farm grown Red Sanders and thus it can be concluded that NEZ has more suitable agro-climatic conditions than other zones. The growth of farm-grown Red Sanders may vary in different age class and in field conditions. It showed that growth of farm grown Red Sanders are highly influenced by edaphoclimatic factors.

6-10 years age class

1-5 years age class

Indian Sandalwood

A field survey was conducted across different agroclimatic zones of Tamil Nadu in order to assess the edapho-climatic influence on growth and wood quality of farm grown sandal. The growth and yield was estimated under different age class viz., 0-5 years, 5-10 years and 10-15 years. The study concluded maximum yield under North Western zone of Tamil Nadu followed by Cauvery Delta Zone and least under North Eastern Zone. Considering the optimum spacing for the *Santalum album*, the spacing treatments of 12 x 12 ft was found better for planting *Santalum album* with more growth biometrics and maximum volume of wood followed by 10 x 10 ft, 8 x 8 ft, 18 x 18 ft and 15 x 15 ft spacing.

Carbon sequestration studies of farm grown Teak

The carbon sequestration potential of farm grown teak was assessed in block and boundary plantations of different agro climatic zones Tamil Nadu. The field study concluded maximum carbon sequestration potential for teak grown under North Western Zone (Table 2) for block plantations and North Eastern Zone (Table 3) for boundary plantations.

Table 2. Carbon sequestration potential of teak in block plantations [Agroclimatic climatic zone: North Western zone and Age: 15-20 years]

S.No	AGB (MT ha^{-1})	BGB (MT ha^{-1})	TB (MT ha^{-1})	TC (MT ha^{-1})	Tt CO_2 (MT ha^{-1})
1	0.2021	0.0525	0.2546	0.1273	0.4672
2	0.1405	0.0365	0.1770	0.0885	0.3248
3	0.2434	0.0633	0.3066	0.1533	0.5627
4	0.2133	0.0555	0.2688	0.1344	0.4932
5	0.2439	0.0634	0.3073	0.1537	0.5639
6	0.1804	0.0469	0.2273	0.1136	0.4171
7	0.2349	0.0611	0.2959	0.1480	0.5430
8	0.1355	0.0352	0.1707	0.0854	0.3133
9	0.1573	0.0409	0.1982	0.0991	0.3637
10	0.2329	0.0606	0.2935	0.1467	0.5385
11	0.3147	0.0818	0.3965	0.1982	0.7276
12	0.2042	0.0531	0.2573	0.1286	0.4721
13	0.3013	0.0783	0.3796	0.1898	0.6966
14	0.2152	0.0560	0.2712	0.1356	0.4976
15	0.2613	0.0679	0.3292	0.1646	0.6041
16	0.1608	0.0418	0.2026	0.1013	0.3718
17	0.3037	0.0790	0.3827	0.1913	0.7022
18	0.2774	0.0721	0.3496	0.1748	0.6415
19	0.1561	0.0406	0.1966	0.0983	0.3608
20	0.2393	0.0622	0.3015	0.1507	0.5532
Avg	0.2209	0.0574	0.2783	0.1392	0.5107

Table 3. Carbon sequestration potential of teak in boundary plantations [Agroclimatic climatic zone: North Eastern zone and Age: 15-20 years]

S.No	**AGB (MT ha^{-1})**	**BGB (MT ha^{-1})**	**TB (MT ha^{-1})**	**TC (MT ha^{-1})**	**Tt CO_2 (MT ha^{-1})**
1	0.1717	0.0446	0.2163	0.1082	0.3969
2	0.5990	0.1557	0.7547	0.3773	1.3849
3	0.3724	0.0968	0.4692	0.2346	0.8610
4	0.1730	0.0450	0.2180	0.1090	0.4000
5	0.3456	0.0899	0.4355	0.2177	0.7991
6	0.0873	0.0227	0.1101	0.0550	0.2020
7	0.3857	0.1003	0.4860	0.2430	0.8917
8	0.1583	0.0412	0.1995	0.0997	0.3661
9	0.4067	0.1057	0.5124	0.2562	0.9402
10	0.5747	0.1494	0.7241	0.3621	1.3288

11	0.9902	0.2575	1.2477	0.6239	2.2895
12	0.1812	0.0471	0.2284	0.1142	0.4190
13	0.6615	0.1720	0.8335	0.4168	1.5295
14	0.3974	0.1033	0.5007	0.2503	0.9187
15	0.1880	0.0489	0.2369	0.1184	0.4347
16	0.3917	0.1018	0.4935	0.2468	0.9056
17	0.0894	0.0232	0.1126	0.0563	0.2066
18	0.3978	0.1034	0.5012	0.2506	0.9197
19	0.1617	0.0421	0.2038	0.1019	0.3740
20	0.4171	0.1085	0.5256	0.2628	0.9644
Avg	**0.3575**	**0.0930**	**0.4505**	**0.2252**	**0.8266**

Silviculture for potential tree gums

There are a large number of trees that exude gums and resins. Tree gums and resins occupy a prime place among Non-Timber Forest Produce (NTFP) and perhaps the most widely used in food, pharmaceutical and cosmetic industries. Forest College and Research Institute has developed technology for processing of Tamarind seed Gum which has wide applications in food and medicinal industries. Apart from tamarind gum extraction, gum yielding trees such as *Moringa oleifera, Azhadirachta indica, Lannea coromandelica, Chloroxylon swietenia, Anogesisus latifolia, Acacia senegal, Butea monosperma, Vachellia nilotica, Azadirachta indica, Acrocarpus fraxinifolius* were assembled at tree gum garden at FC&RI, Mettupalayam. Technologies on gum tapping and value addition of tree based gums were envisaged for productive utilization of resources.

Plate 10. Gum exudation in *Chloroxylon swietenia*

Technology Transfer

The technologies developed for tree farming at Forest College and Research Institute, Mettupalayam is adopted and transferred to farmers across Tamil Nadu. The details of the farm extension activity are listed below:

Number of farmers directly visited the research field	163
Number of farmers contacted by phone	1254
Total number of queries addressed	1417

Conclusion

The fast economic development of the country and the increasing consumption pattern of the wood tremendously increase the demand for wood and wood products. In order to meet the growing demand, the present scenario of total import of wood will not help for sustainable development of the country. Rather a robust promotion of tree cultivation outside the forest area particularly in farmlands with precision technology of tree farming not only helps for economic development of the country but also become socially relevant in terms of income generation and environment sustainability in the changing climate era. Due to vagaries of failures in agriculture can be conveniently managed by introducing appropriate tree farming techniques with improved practices to make climate resilient agriculture ecosystem in the country.

1.5/Lead Paper

Biotechnological Interventions in Tree Improvement: An Overview

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Abstract: Trees are an essential component of the world's ecosystems, providing numerous benefits such as oxygen production, carbon sequestration, climate change mitigation, livelihood security, industrial growth, and habitat for wildlife. However, trees are also vulnerable to a range of threats, including disease, pests, deforestation and habitat destruction, lack of genetic diversity, and environmental stressors, which can limit their growth and productivity. To overcome these challenges, biotechnological interventions have been developed to improve the genetic makeup of trees, improve, or develop specific traits to enhance their resilience, and ensure their long-term viability in the face of these challenges. Biotechnological interventions in tree improvement have the potential to bring significant benefits to both communities and industries. By improving the genetic quality of tree species, biotechnology can help to increase the productivity and profitability of forestry and agroforestry operations. This, in turn, can enhance the livelihood security of communities that depend on these resources for their income and well-being.

Introduction

Tree improvement refers to the process of enhancing the genetic quality of a tree species through selective breeding, hybridization, genetic engineering, or other methods. The goal of tree improvement is to produce trees that have desirable traits such as faster growth, improved wood quality, resistance to pests and diseases, and improved adaptability to environmental conditions. On the other hand, biotechnology refers to the use of living organisms, cells, or biological systems to produce useful products and solve problems. In the context of trees, biotechnology can be used to improve the genetic quality of trees through techniques such as genetic engineering, where specific genes are introduced into the tree's genome to confer desirable traits. Biotechnology can also be used to produce clonal trees through tissue culture, where a small piece of tissue from a desirable tree is used to produce many genetically identical trees. Both tree improvement and biotechnology have the potential to play an important role in meeting the increasing demand for wood and other forest products, as well as in addressing environmental challenges such as deforestation and climate change.

The history and development of biotechnological techniques in tree improvement:

The use of biotechnological techniques in tree improvement can be traced back to the early 20th century when scientists first began to experiment with hybridization and selection methods to improve the quality and yield of forest trees. During this time, traditional breeding techniques such as cross-pollination and selection for desired traits were used to create new tree varieties. However, these methods were limited by the long generation time of trees and the difficulty of transferring desirable traits from one species to another. In the late 20th century, the advent of biotechnology revolutionized tree improvement. Techniques such as tissue culture, genetic engineering, and molecular biology provided new tools for researchers to accelerate the breeding process and achieve more precise control over the expression of specific traits in trees (Haines 1993).

One of the most significant advancements in tree biotechnology was the discovery of *Agrobacterium tumefaciens*, a bacterium that naturally transfers DNA from one organism to another. This discovery paved the way for the development of genetic engineering, which allows scientists to precisely introduce new genes into the genomes of trees. This has allowed for the introduction of traits such as increased resistance to pests and diseases, improved wood quality, and enhanced growth and productivity. Another important development in tree biotechnology has been the use of tissue culture and somatic embryogenesis to produce clonal trees. This process involves the culture of cells or tissues in a sterile environment, which can then be used to produce genetically identical trees. This allows for the rapid propagation of desirable traits and the mass production of genetically improved trees.

More recent biotechnological techniques that have been developed for use in tree improvement include gene silencing and genome editing. Gene silencing involves the suppression of specific genes to modify the tree's traits, while genome editing involves the precise modification of specific genes within the tree's genome using techniques such as CRISPR/Cas9 (Bortesi and Fischer 2015). These techniques have the potential to be even more precise and targeted than traditional genetic engineering techniques, and they have the potential to be used for a wide range of applications in tree improvement.

Scope of Biotechnological Interventions in Tree Improvement:

The scope of biotechnological interventions in tree improvement is vast and covers a wide range of techniques and applications. Some of the key areas of biotechnology in tree improvement include:

1. Genetic engineering: This involves the introduction of specific genes into the genome of a tree to confer desirable traits, such as resistance to pests and diseases, faster growth, improved wood quality, and improved adaptability to environmental conditions (Thakur et al., 2011).
2. Tissue culture and clonal propagation: This technique produces genetically identical trees from a single piece of tissue, such as a leaf or shoot, of a desirable tree. This allows for the rapid production of large numbers of trees with desirable traits (Thakur and Karnosky, 2007).
3. Molecular markers and genomic selection: Molecular markers and genetic information is used to identify and select trees with desirable traits. This allows for the efficient selection of trees with desirable traits, such as resistance to pests and diseases, faster growth, and improved wood quality (Goto et al., 1998; Ishii et al., 1999; Thakur and Ishii, 2011).
4. Cryopreservation and *in vitro* storage: These are techniques used to preserve plant material and genetic resources. Cryopreservation involves preserving seeds, pollen, and tissue samples at ultra-low temperatures, providing a backup for genetic resources. *In vitro* storage allows for preserving tissue samples in nutrient-rich solutions in laboratory conditions, providing a valuable resource for biotechnological interventions and the preservation of endangered or rare species. Together, these techniques provide important tools for preserving genetic resources and maintaining genetic diversity, critical for the success of tree improvement programs and sustainable forest management (Thakur and Karnosky, 2007).
5. *In vitro* selection: This involves selecting desirable plant material in laboratory conditions. Tissue samples are grown in nutrient-rich solutions and evaluated for desirable traits such as resistance to pests and diseases, faster growth, improved wood quality, and improved adaptability to environmental conditions. The best tissue samples are then selected and used to produce new plants or tissue culture material for further improvement. *In vitro* selection provides an efficient and controlled environment for the selection and improvement of desirable traits in trees and can be used to develop improved tree varieties and preserve endangered or rare species.
6. Somaclonal variation: It occurs during tissue culture and clonal propagation of trees. It refers to the occurrence of genetic variations in tissue culture-derived plants that are not present in the original parent plant. This can result in the production of plants with new or altered traits, such as changes in growth habits, flower color, or disease resistance. While somaclonal variation can provide a source of new genetic variation, it can also result in the production of plants with undesirable traits. It is important to carefully evaluate tissue culture-derived plants for desirable traits before their commercial release (Goto et al., 1998; Thakur et al. 1999).
7. Protoplast fusion: It involves the fusion of plant cells to produce new, genetically unique plants. By fusing protoplasts from different plant species or varieties, novel genes can be introduced and interspecific hybrids with improved traits can be produced. Protoplast fusion is a valuable tool for tree improvement, but it is important to carefully evaluate its safety and environmental impact before commercial release.
8. Haploid cultures: These are biotechnological process in tree improvement that involves the production of plant cells or plants with only one set of chromosomes. This allows for the rapid

production of homozygous plants with identical sets of genes and uniform, stable, and predictable genetic characteristics. Haploids can be produced through various methods and can help to address the demand for wood and other forest products by providing a more efficient and faster production of homozygous plants for tree improvement programs.

The advantages of biotechnological interventions in tree improvement:

There are several advantages to using biotechnological interventions in tree improvement, including:

1. Increased precision: Biotechnology provides tools for precise genetic manipulation, allowing scientists to introduce specific traits into trees with high accuracy. This is a significant improvement over traditional breeding methods, which are often limited by the difficulty of transferring desired traits from one species to another.
2. Faster breeding cycles: Biotechnology techniques, such as tissue culture and somatic embryogenesis, allow for the rapid propagation of genetically improved plants (Thakur et al., 1998). This significantly speeds up the breeding process, which can take many years with traditional breeding methods.
3. Improved resistance to pests and diseases: Biotechnology has allowed for the introduction of genes that provide trees with resistance to pests and diseases, reducing the need for chemical treatments and improving the overall health of forests.
4. Enhanced growth and productivity: Biotechnology has led to the development of trees with improved growth rates and increased productivity, providing a valuable resource for the forest products industry.
5. Better wood quality: Biotechnology has enabled the introduction of genes that improve wood quality, such as increased density and strength, providing benefits for the construction and manufacturing industries.
6. Increased adaptability: Biotechnology has allowed for the development of trees that are better adapted to changing climatic conditions, improving their ability to thrive in a variety of environments (Cseke et al., 2005).
7. Reduced environmental impact: By improving the quality and productivity of trees, biotechnology has the potential to reduce the environmental impact of forest products, such as paper and lumber, by reducing the need for additional land to be cleared for forestry.

The potential risks and challenges of biotechnological interventions in tree improvement:

Despite the many advantages of biotechnological interventions in tree improvement, several potential risks and challenges must be considered, including:

1. Public acceptance: The use of biotechnology in tree improvement can be controversial, and there may be resistance from the public due to concerns about safety and environmental impacts. This can be a major challenge for the widespread adoption of these technologies.
2. Regulatory barriers: Biotechnology is heavily regulated in many countries, and the approval process for genetically modified trees can be lengthy and complex. This can be a significant obstacle to the development and commercialization of improved tree varieties.
3. Environmental impacts: The release of genetically modified trees into the environment can have unintended consequences, such as the transfer of novel traits to related species and the disruption of natural ecosystems. This is a major concern for many scientists and environmental groups.
4. Economic viability: The development and commercialization of genetically modified trees can be expensive, and there is a risk that these costs will not be outweighed by the benefits of the technology.
5. Lack of understanding: There is still much that is not known about the long-term effects of genetically modified trees on the environment and human health, and further research is needed to fully understand the potential risks and benefits of these technologies.
6. Intellectual property: The use of biotechnology in tree improvement can create complex intellectual property issues, such as disputes over ownership of patented genes and technologies.

The regulatory framework for biotechnological interventions in tree improvement:

The regulation of biotechnological interventions in tree improvement varies between countries and regions, but in general, the use of genetically modified (GM) trees is subject to a range of legal and regulatory requirements (Sederoff R, 2007).

In the United States, the regulation of GM trees is primarily the responsibility of the United States Department of Agriculture (USDA) and the Environmental Protection Agency (EPA). The USDA is responsible for regulating the movement, release, and commercialization of GM trees, while the EPA regulates the use of pesticides, including those used on GM trees.

In India, the top biotech regulator in India is Genetic Engineering Appraisal Committee(GEAC). The committee functions as a statutory body under the Environment Protection Act 1986 of the Ministry of Environment & Forests (MoEF).

In Europe, the regulation of GM trees is governed by the European Union's regulations on genetically modified organisms (GMOs). These regulations require that GMOs undergo a comprehensive risk assessment before they can be released into the environment, and they provide for a mandatory labeling and traceability system for GM products.

In many other countries, the regulation of GM trees is still in its early stages, and there may be varying levels of regulatory oversight and control. However, international organizations such as the Convention on Biological Diversity and the Cartagena Protocol on Biosafety have established guidelines for the safe use and handling of GMOs, including GM trees.

The regulation of biotechnological interventions in tree improvement is complex and evolving, and scientists and industry groups need to stay informed about the latest developments in this area. The regulatory framework for GM trees must balance the need for the safe and effective use of these technologies with the need to protect the environment and human health.

Current and future trends in biotechnological interventions in tree improvement:

Biotechnological interventions in tree improvement are a rapidly growing field, with ongoing research to develop trees that are more productive, resistant to pests and diseases, and better adapted to changing environmental conditions (Cseke et al., 2005). These technologies have the potential to significantly improve the sustainability and profitability of the forest products industry, and there are several current and future trends in this area:

1. <u>Increased use of CRISPR/Cas technology:</u> CRISPR/Cas technology is a powerful tool for precise genetic engineering, and it is becoming increasingly popular in tree improvement research. This technology allows for the efficient and precise insertion of genes into the tree genome, providing a more efficient way to introduce desired traits into trees.
2. <u>Development of drought-tolerant trees:</u> Climate change is leading to increased drought conditions in many regions, and there is growing interest in the development of trees that are more drought-tolerant. Biotechnology is providing a means to introduce drought tolerance genes into trees, improving their ability to withstand water stress.
3. <u>Improved resistance to pests and diseases:</u> Pests and diseases are a major threat to forests and the forest products industry, and there is ongoing research to develop trees with improved resistance to these challenges. Biotechnology is providing a means to introduce resistance genes into trees, reducing the need for chemical treatments and improving the overall health of forests.
4. <u>Increased focus on sustainable forestry:</u>Sustainable forestry practices and biotechnology is providing a means to develop trees that are better adapted to changing environmental conditions and that require fewer inputs such as water, fertilizer, and pesticides.
5. <u>Improved wood quality:</u> There is ongoing research to develop trees with improved wood quality, including increased density and strength, providing benefits for the construction and manufacturing industries.
6. <u>Commercialization of genetically modified trees:</u> While the commercialization of genetically modified trees has been slow to date, there are increasing signs that this trend is changing, with a growing number of companies investing in the development of improved tree varieties.

Notable examples of biotechnological interventions in tree improvement:

There have been several notable examples of biotech interventions in tree improvement, including:

1. Drought-tolerant Poplar and Teak trees: Researchers have developed poplar and teak trees that are more resistant to drought by introducing genes from wild relatives of the species that are naturally adapted to dry conditions. These trees show improved survival and growth under water-limited conditions, providing benefits for the bioenergy and paper production industries.
2. Insect-resistant Pine and Poplar trees: Pine and poplar trees are a major source of wood products, but they are also susceptible to a wide range of pests and diseases. Researchers have developed pine and poplar trees that are more resistant to insect damage by introducing foreign genes toxic to certain insects. In poplar, trees have been modified to express a protein from the *Bacillus thuringiensis* (*Bt*) bacterium (Cao et al., 2010). These genetically modified poplar trees have shown reduced damage from insect pests, such as the gypsy moth and the cotton bollworm, providing benefits for the forestry industry.
3. Faster-growing Eucalyptus trees: Eucalyptus is a fast-growing species that is widely used in India for the production of paper, wood products, and bioenergy. Researchers have developed eucalyptus trees that grow even faster by introducing genes that regulate growth and development. These trees have improved growth rates, providing benefits for the forestry and bioenergy industries.
4. Improved Wood Quality in Poplar trees: Poplar trees are widely used to produce paper and bioenergy, but their wood quality can be improved. Researchers have developed poplar trees with improved wood quality by introducing genes that regulate the production of lignin, a key component of wood. These trees have improved wood density and strength, providing benefits for the construction and manufacturing industries.
5. Enhanced Carbon Sequestration in Trees: There is growing interest in the role of trees in mitigating climate change by removing carbon dioxide from the atmosphere and storing it in the form of wood. Researchers have developed trees with enhanced carbon sequestration capabilities by introducing genes that regulate photosynthesis and carbon uptake. These trees have the potential to remove more carbon dioxide from the atmosphere, providing benefits for the environment and mitigating the effects of climate change.

These are just a few examples of the many biotechnological interventions in tree improvement that are currently underway. These technologies have the potential to significantly improve the sustainability and profitability of the forest products industry, and there is growing interest in their development and commercialization.

Conclusion

Biotechnology also has a tremendous potential to significantly improve crops and tree improvement efforts within the context of a tree-Based diversified land-use system. Biotechnological interventions can help to increase the speed and precision of breeding programs, leading to the faster development of new varieties that are better suited to local conditions. This can include techniques such as genetic engineering, which can allow scientists to insert specific genes into plants to confer desired traits such as disease resistance or improved growth rates. Biotechnology can also help to identify the genes responsible for key traits, which can facilitate a more precise selection of superior plants for breeding purposes.

These interventions can eventually have a positive impact on the livelihood security of communities and the industrial growth of the forest sector. For example, improved tree varieties with enhanced growth and wood quality can increase the productivity of forests, providing more wood and other forest products for commercial use. This, in turn, can create more job opportunities and increase the income of communities that depend on forests for their livelihoods. Moreover, the use of biotechnological interventions can also help to conserve endangered or rare tree species, preserving their genetic resources and helping to maintain the genetic diversity of tree species. This is critical for the long-term sustainability of forests and the forest sector and can help to ensure the continued availability of wood and other forest products for future generations.

In summary, biotechnological interventions in tree improvement can play an important role in enhancing the livelihood security of communities and promoting industrial growth in the forest sector, while also contributing to the conservation of genetic resources and the sustainable management of forests.

References

Bortesi L, and Fischer R 2015. The CRISPR/Cas9 system for plant genome editing and beyond. Biotechnol. Adv. 33, 41–52.

Cao C W, Liu GF, Wang ZY, Yan SC, Ma L, and Yang C P 2010. Response of the gypsy moth Lymantria dispar to transgenic poplar *Populus simonii* × *P. nigra* expressing fusion protein gene of the spider insecticidal peptide and Bt -toxin C-peptide. J. Insect Sci. 10, 1–13.

Cseke LJ, Cornwell SB, Shankar A, Sen B, Taylor LC, Thakur R, Karnosky DF, and Podila GK 2005. SEP-class genes in *Populus tremuloides*and their likely role in reproductive survival of poplar trees. Gene 358 (2005) 1-16.

Goto S, Thakur RC, and Ishii K (1998) Determination of genetic stability in long-term micropropagated shoots of *Pinus thunburgii*Parl. using RAPD markers. Plant Cell Reports 18: 193-197.

Haines R 1993. Biotechnology in forest tree improvementwith special reference to developing countries. FAO Forestry Paper No. 118.

Ishii K, Thakur RC, and Jain SM (1999). Somatic embryogenesis and evaluation of variability in somatic seedlings of *Quercus serrata* by RAPD markers In: *Somatic Embryogenesis in Woody Plants*. SM Jain, PK Gupta, and RJ Newton (eds.), vol. 4. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp 403-414.

Sederoff R 2007.Regulatory science in forest biotechnology. Tree Genetics & Genomes (2007) 3:71–74

Thakur RC, and Karnosky DF 2007. Micropropagation and germplasm conservation of Central Park Splendor Chinese elm (*Ulmusparvifolia*Jacq. 'A/Ross Central Park') Trees. Plant Cell Reports DOI 10.1007/s00299-007-0334-7. Plant Cell Rep. 26(8):1171-7.

Thakur RC, and Ishii K 2011. Detection and fingerprinting of narrow-leaf mutants in micro-propagated hybrid poplar (Populus sieboldii x P grandidentata) using random amplified polymorphic DNA. International Journal of Farm Sciences 2(1): 79-84

Thakur RC, Cseke LJ, Kirakosyan A, and Kaufman PB 2011 Gene Transfer and Expression in Plants. *In:* L.J. Cseke, A. Kirakosyan, P. B. Kaufman and M. W. Westfall (eds.), Handbook of Molecular and Cellular Methods in Biology and Medicine, Third Edition. CRC Press. pp 637-661.

Thakur RC, Goto S, Ishii K, and Jain SM 1999. Monitoring genetic stability in *Quercus serrata* Thunb. somatic embryogenesis using RAPD markers. Journal of Forest Research 4: 157-160.

Thakur RC, Hosoi Y, and Ishii K (1998) Rapid *in vitro* propagation of *Matteucciastruthiiopteris*(L.) Todaro - an edible fern. Plant Cell Reports 18: 203-208.

1.6/Lead Paper

Subabul (*Leucaena leucocephala*) Clonal Forestry: A Path Forward for Solution of Fibre Resource Development to Paper Industries in India

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Abstract: India is one of the major producers / consumers of paper and pulp products (3 to 4% of global share). Approximately one fourth of its raw material has been wood based and from the years nineteen eighties onwards, there has been a paradigm policy shift to open competitive economy. Development challenges thus faced by the industry since then, includes development of robust raw material base, from clonal agro and farm forestry on farmers/private lands. Following genetic improvement of *Leucaena leucocephala* and realization of its potential as a multiple use species was introduced in India under an international cooperation effort [Swedish International Development Cooperation Agency -SIDA] around 1980 and gained importance. It has spread across the country as a panacea for rural needs of fire wood, small timber, cattle forage, *etc*. During the past 25 years, JK Paper has been a pioneer in developing clonal propagation systems to-regenerate these highly productive plantations. Original clonal selections optimized disease resistance, coppicing ability, and volume growth, while recent priorities have moved to improve volume growth and wood quality. The Indian paper industry also found Leucaena sps to be a potential raw material for paper making. Farmers have getting farm income much more from subabul clonal plantation as compare to traditional agricultural crops. The productivity of subabul clone approximately is per ha 85 MT in 18-20 months in irrigated land and more beneficially plantation to improve soil of the land, micro climate of plantation area and also help to improve the climate.

Introduction

JK Paper Ltd has annual production capacity is about 6,00,000 TPA and having three integrated pulp and paper plants located at Songadh (Gujarat), Rayagada (Orissa) and Kagaznagar (Telangana) producing writing & printing paper and packaging board papers. JK Paper Limited, Unit- CPM is the largest integrated pulp, paper & paperboard manufacturing unit located at Fort: Songadh, Dist: Tapi, Gujarat state in India. The annual production capacity of Unit- CPM is 300,000 paper & paperboards. The annual wood requirement of CPM unit is about 600,000 MT which comprises of primarily *Leucaena*, *Eucalyptus & Casuarina* out of which *Leucaena* is major (About 75%). For sustainable raw material supply, JKPL is promoting clonal agro & farm forestry plantations programme in adjoining to mill’s catchment area from the year 1996-97. Unit CPM provides quality seeds/ improved clones at/on subsidized price & provides free technical support to the farmers and also provides the buyback assurance for their matured wood. JKPL has started its plantation program from 1996 and till 2020-21 186000 Hectare brought under green cover through farm forestry by distributing more than 63 crores plants in last 10 years.

Scenario of Agro and farm forestry in India:

India is a wood fiber deficient country. Inadequate raw material availability domestically is a major constraint for the Paper Industries. Paper Industries in India are not a forest-based industry but is an agro and farm forestry-based industry. India’s paper industry has agro forestry roots and strong backward linkages with the farming community, from whom wood, which is a key raw material, is sourced. The total demand for wood, over 90% is sourced from industry-driven agro and farm forestry plantations, with the rest from the government and other sources. India’s paper industry is wood-positive that is, it plants more trees outside forest than it harvests.

Pioneering work has been carried out by the paper industry over the last three decades in producing quality and disease resistant clonal plants of Eucalyptus, Subabul, Casuarina and Acacia. Substantial amounts have been spent by the paper industries on plantation R&D, production of high-quality clonal saplings, technical and extension services to farmers for improving the agro and farm forestry plantations.

In India, an estimated 500,000 farmers are engaged in growing plantations of Eucalyptus, Subabul, Casuarina, Acacia and Poplar. On average, about 125,000 hectares are being brought under agro and farm forestry on an annual basis, with around 1.2 million hectares on a cumulative basis across the country, due to intensive efforts mounted by paper mills over the last several years. This has generated significant employment opportunities for the local community, especially in the rural areas, and also significantly supplemented the income of farmers and helped check the rural-urban distress migration. Additionally, this has had significant environmental benefits in terms of an increase in the country's green / tree cover, carbon sequestration, restoration of degraded land, mitigating climate change, etc. These working or managed forests support the environment, providing clean air, clean water through increased rainfall, wildlife habitat and carbon storage (IPMA report).

Environmental benefits of clonal forestry

CO_2 Absorption

The value of JK Paper Ltd farm forestry program is immense in mitigating environmental degradation. Apart from increasing greenery and tree cover, farm forestry has significant potential for carbon storage. Estimated quantities of CO2extracted from the air and C stored byfarm forestry during the period 2009-10 to 2020-21.

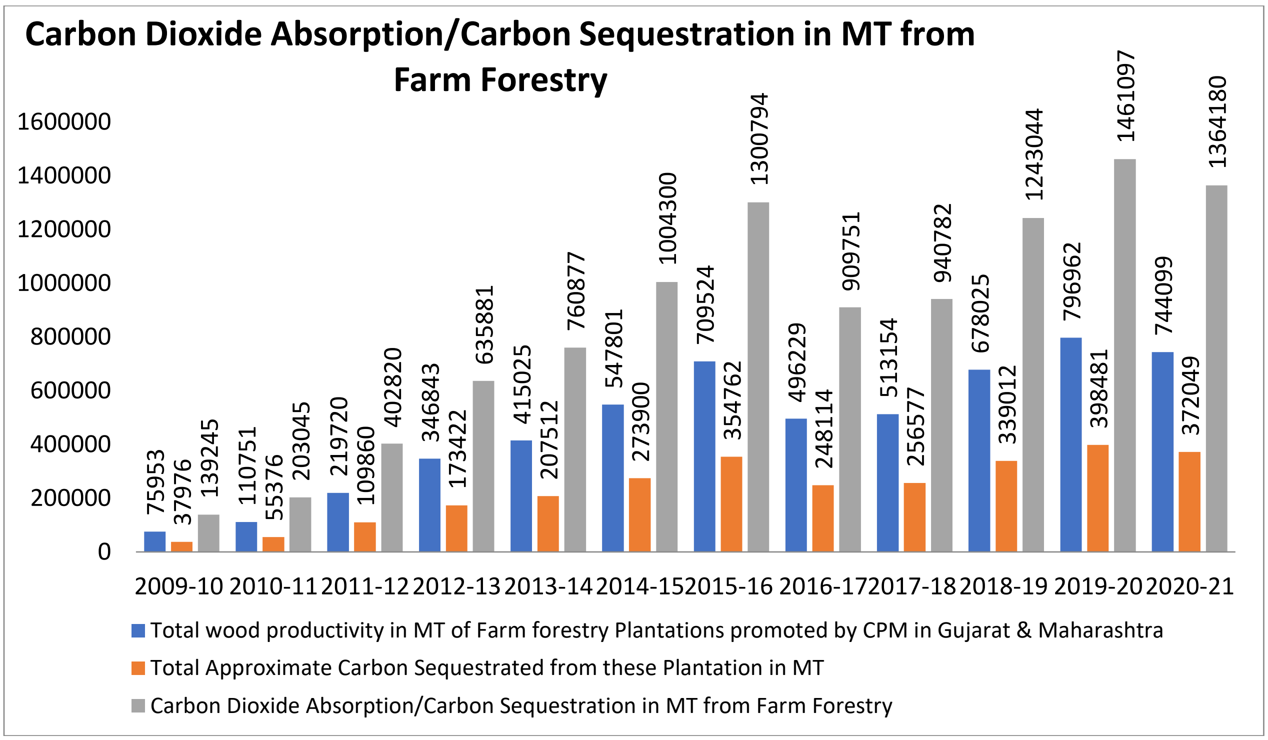

Fig.1. Carbon dioxide absorption in MT from clonal farm forestry in Gujarat

Subabul (*Leucaena leucocephala*) is wide spread species in world, originated in Central America and Mexico. Leucaena was transferred to Asia from west Mexico in 16th and 17th centuries at the time of Galleon trade. Leucaena is also spread in South America, Asia, Southern Europe, Australia, Africa and many Oceanic islands with warm climates.

In India, Leucaena was introduced mainly as an agro-forestry crop to meet the increasing demand for fuel, fodder and timber for poles and posts.

In India, Subabul is widespread across country mainly planted and cultivated in Andhra Pradesh, Telangana, Maharashtra and Gujarat. Plantations of subabul in these states are 3 lakhs hectares to produce sustainable approximate 80 lakh MT wood per annum, which is used by pulp and paper industries, power plants, fuel wood and other industrial and domestic uses. The annual purchase turnover of the Subabul wood in above states is approximately 2400 crore paid to small and marginal farmers' community. Subabul wood requirement will be double in next 5 years i.e. 2026-27 by expansion of the paper industries and massive introduction of particle & MDF board industries in Subabul growing areas.

The major constraint faced by Subabul planting farmer is wood productivity per hectare which is 60-70MT in 3 years rotation cycle that is a reason why large area is required for production of 80 lakh MT of wood in 4 major Subabul wood producing states and farmers remuneration is lower side from per unit of hectares, hence so many farmers are migrating to other agricultural crops.

In view to focus in genetic improvement of *Leucaena leucocephala*, it is found that very few researches are available in tree improvement in view of wood productivity worldwide, major research has been done in Australia for fodder and energy trait improvement for cattle feeding to promote meat industries.

To focus in the wood productivity in Leucaena we have started tree improvement program in 2014-15 by inter specific hybridization, selection from diverse population and mutation through gamma radiation. JKPL has focused on these tree improvement methods which were applied consistently from 2015 to 2021 and positive results have been observed in improvement of wood productivity and tree morphology.

1) Selection of superior genome through phenotypic identification for its superiority over natural population will be called plus tree, which was coppiced and produced clone in vivo & in vitro technology.
2) Its progeny trials have been conducted in situ of identified superior plus trees to ensure its genetic replication in the progeny as superior to plus trees.
3) Field trials to ensure the replication of the plus trees genome.
4) Mass scale multiplication in vivo and in vitro.
5) Mass scale planting by farmers for commercial uses.
6) Pulp quality, chemical consumption, pulp viscosity, pulp brightness, cooking condition for pulp yield for Leucaena wood samples collected from 6 Candidate Plus Trees (CPTs).

Productivity improvement through Candidate Plus Trees (CPTs):

In order to have a broader genetic base and to improve yield per unit area, a systemic genetic approach in research and development of Leucaena is being under-taken. Selection of CPTs is done in Gujarat and Maharashtra States at different sites. 3500 CPTs have been selected. A further short list of the top 10CPTs were selected for testing of pulping properties at our R&D laboratory. Screened pulp yield (pulp/fiber % of wood) of these clones is higher than the present average screened pulp yield of commercialized Leucaena clones by 1-2%.

Subabul Clone Production Technology:

Individual trees are first selected in existing plantations for the morphological characteristics of growth, health, and branching patterns. Trees can be selected as early as three years after planting. Selected trees are then cut down and the coppice sprouts are used to vegetatively propagate a number of cuttings sufficient for a field-testing program. Simultaneously, wood samples are analyzed for wood properties such as lignin content, specific gravity, and fiber length. Clonal tests are conducted on a variety of sites, with each of these sites carefully characterized by thorough in-house soil testing and analysis. Final selection for inclusion in the planting program is based on field performance, nursery performance (including rootability), and wood properties. Once selected, clones are then plakhed in a clone bank to be used for mass propagation.

Clonal hedge garden techniques:

A naturally ventilated polyhouse covered with 200-micron polythene stabilized against UV rays and provided with a fertigation system, plus temperature and humidity controllers, was constructed. Superior mother plants wereplanted in raised beds filled with pure sterilized sand at 10×10 cm spacing. Required fertilizer dosages were pro- vided to the plants through the fertigation system and constant humidity and temperature were maintained. Every month about 3 to 4 juvenile coppice cuttings were obtained from each mother plant. The adequate nutritionalstatus of the mother plants was important in increasing therooting percentage of cuttings in the misting chamber.

Clonal Propagation techniques:

Coco peat and semi carbonized rice husk in 70%+30% ratio were used for clonal propagation as it has low salinity as measured by electrical conductivity (EC). It alsohas excellent water holding capacity and cation exchangecapacity. Fifty ml, 60 cell plastic root trainer blocks wereused for production of clones (Lal, 2001). Misting chambers with appropriate temperature and humidity control systemswere installed over a 4000 m^2 area at the clonal propagation centre in Fort Songadh, Tapi, Gujarat. Every month about 150,000 juvenile apical cuttings are established producing3 million Leucaena clones per annum **(Fig.-10**). Water quality is critical for a successful misting chamber operation. Waterused has a pH of 6.5–7.5, very low electrical conductivity (EC) and sodiumabsorption ratio (SAR) below 3.0. Reverse osmosis water rather than canal or river water is preferable for misting chamberoperation (Brewbaker, 1988).

We have also collected coppice cuttings from these plus trees and have developed rooting methodologies in misting chambers. Progeny testing for these plus trees has been done. Results show that CPM 3, CPM 29 and CPM 32 have 125% growth compared with the control of existing leucaena field clonal plantations. Vegetative multiplication in vivo is going on for commercial production of plant and this year 3 million clones will be planted in Gujarat and Maharashtra during 2021-22. During progeny trial research we have observed that this genetically superior plus tree is very fast growing and produce 85 MT/hectare of wood in 18 months (Table-1 & Fig. 2) whereas normal productivity by seedling through seed is 60-70 MT per hectare in 3 years. This clone is game changer in farmers field for their economic viability as compared to their routine agriculture crops in Gujarat and Maharashtra. Farmers will get Rs. 1.60 Lakhs net income per Ha/year and total income Rs. 2.40 Lakhs per Ha in 18 months by planting of this clone whereas in agriculture crop both the cycle cotton and wheat farmers get approx 120000/Ha/year net income which is 33% higher than wheat/cotton (Table-2).

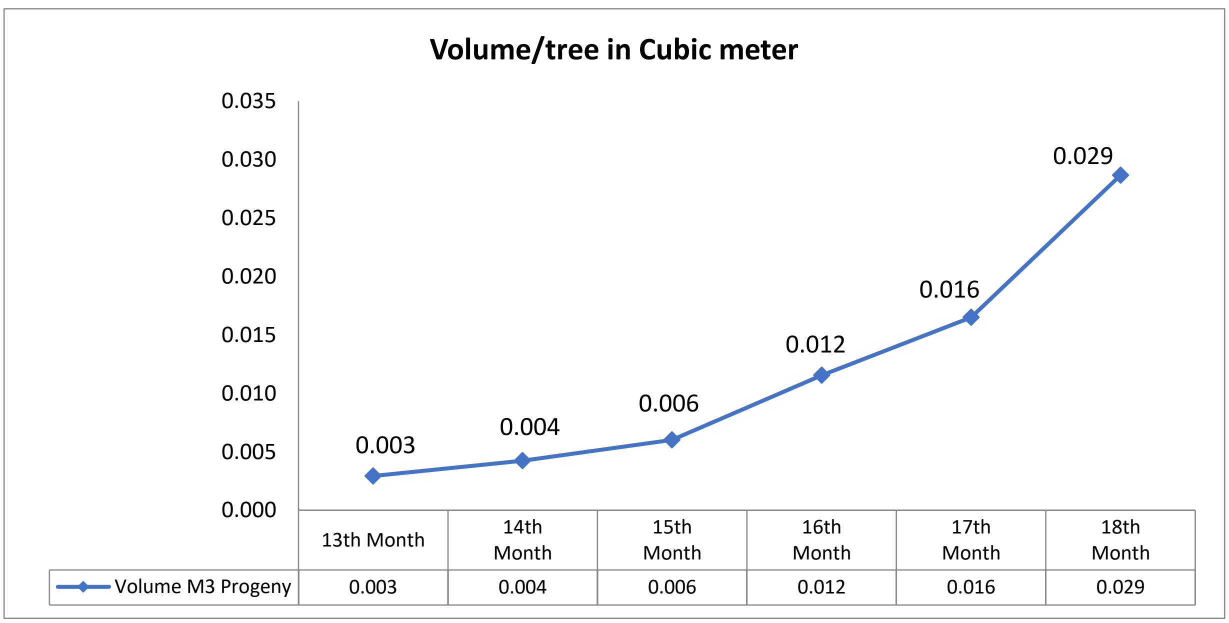

Fig. 2. Graphs showing Average productivity of Subabul CPM-32 clone per tree:

Table 1. Field data of F1 Progeny trial of Subabul clone CPM-32

Nos of plants /ha@85% survival	Average vol./plant	Total vol./ha on age 18 months in MT	Vol.//ha on age 12 months in MT
4600	0.029	85	56

Table 2. Economic comparison of subabul clone CPM-32 with agriculture crops

Particulars	Subabul Clone (1.5 Years)	Cotton (1 year)	Wheat (4 months)
Total Investment	40000	62500	22000
Total Yield (MT)	85	3.0	2.5
Sale Price- Average standing at farm gate (Rs./MT)	3300	52000	19500
Total Revenue (Rs.)	**280500**	**156000**	**48750**
Expenditure (Rs.)	40000	62500	22000
Net Income (Rs.)	**240500**	**93500**	**26750**
Net Income (Rs./ha/year)	**160333**	**93500**	**26750**
Net Income (Rs./acre/year)	**64133**	**37400**	**10700**

Table 3. Comparison of harvesting period and Yield/Ha/Year in India vs abroad

Country	Species/Clone	Spacing in mt	Nos of plants/ha @90% survival	Rotation of plantation in years	Yield / ha /year in MT
India	Subabul CPM 32	1.5 x 1.2	4600	1.5	56
Brazil	Eucalyptus	3.0 x 1.5	2000	7.0	45
Indonesia	Acacia/ Eucalyptus	3.0 x 1.5	2000	6.0	35
India	Eucalyptus	3.0 x 1.5	2000	4-5	35 to 40

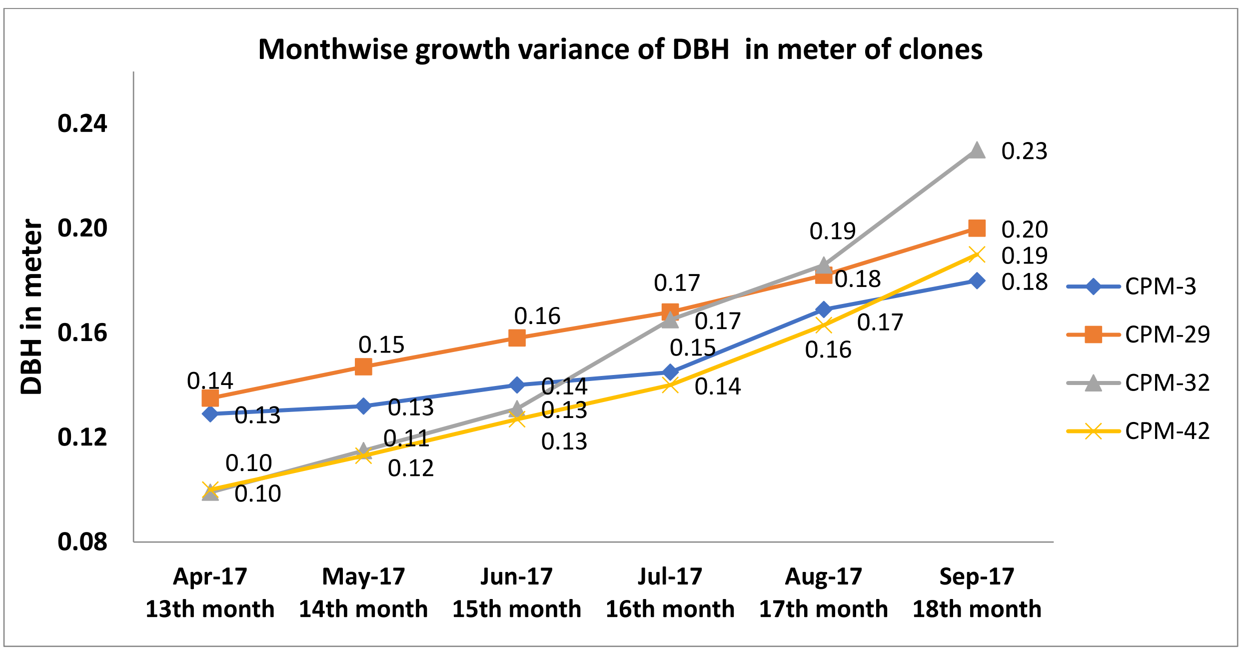

Fig. 3. Monthwise growth variance of DBH in meter of subabul clones

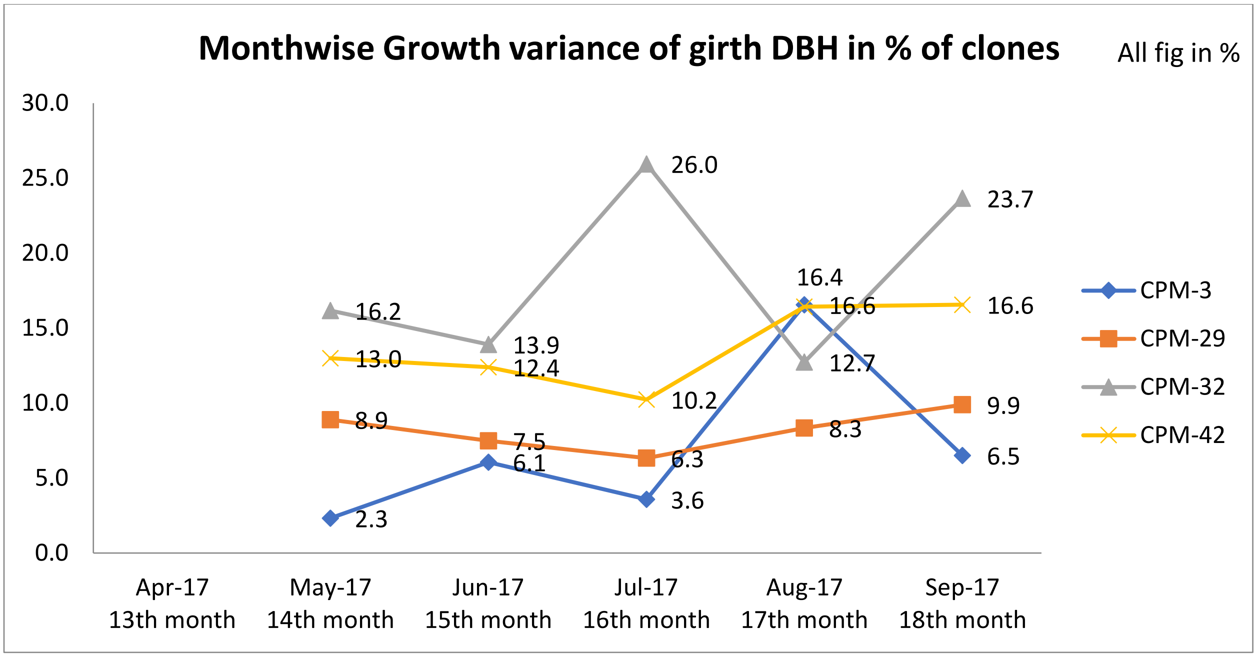

Fig. 4. Monthwise growth variance of DBH in % of subabul clones

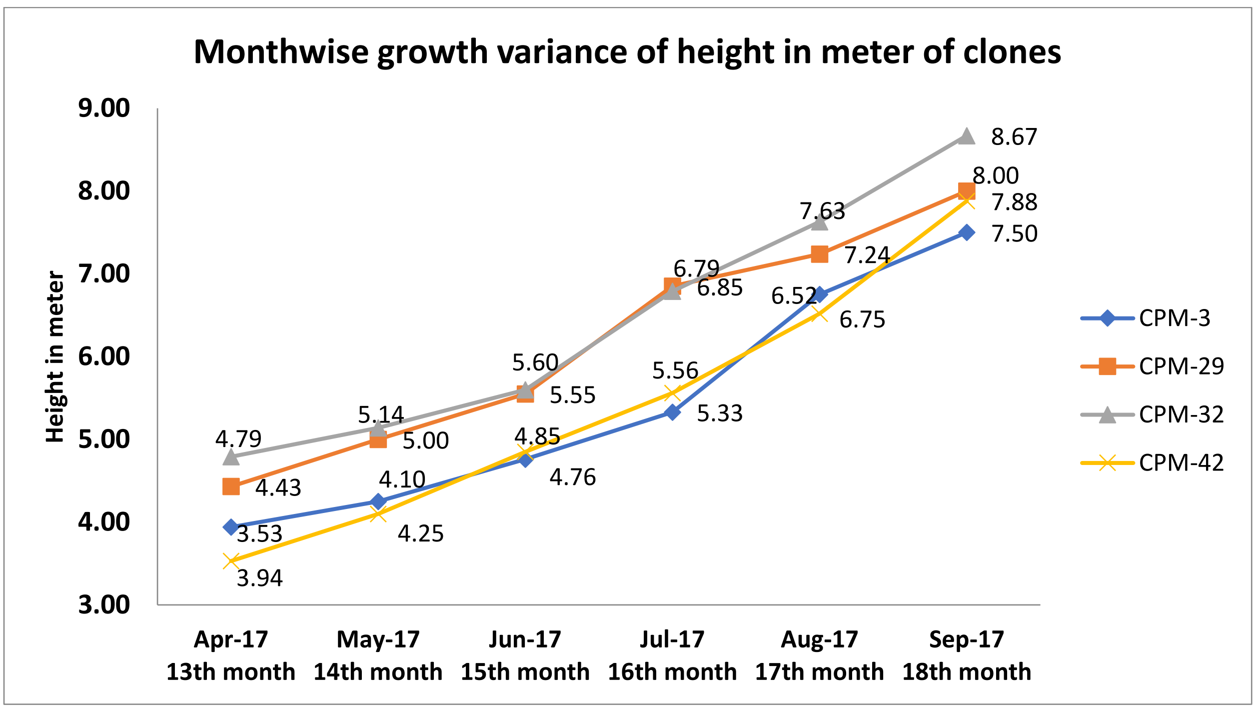

Fig. 5. Monthwise growth variance of height in meter of subabul clones

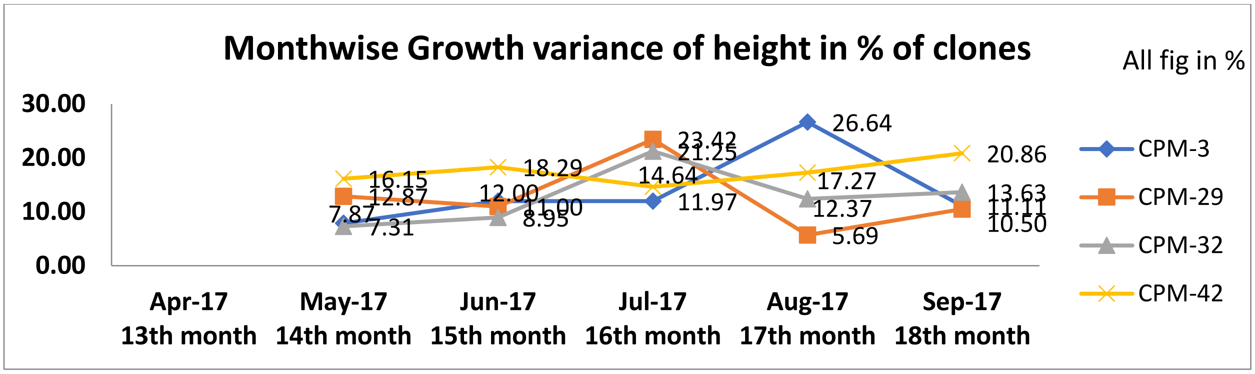

Fig. 6. Monthwise growth pattern of height in % of subabul clones

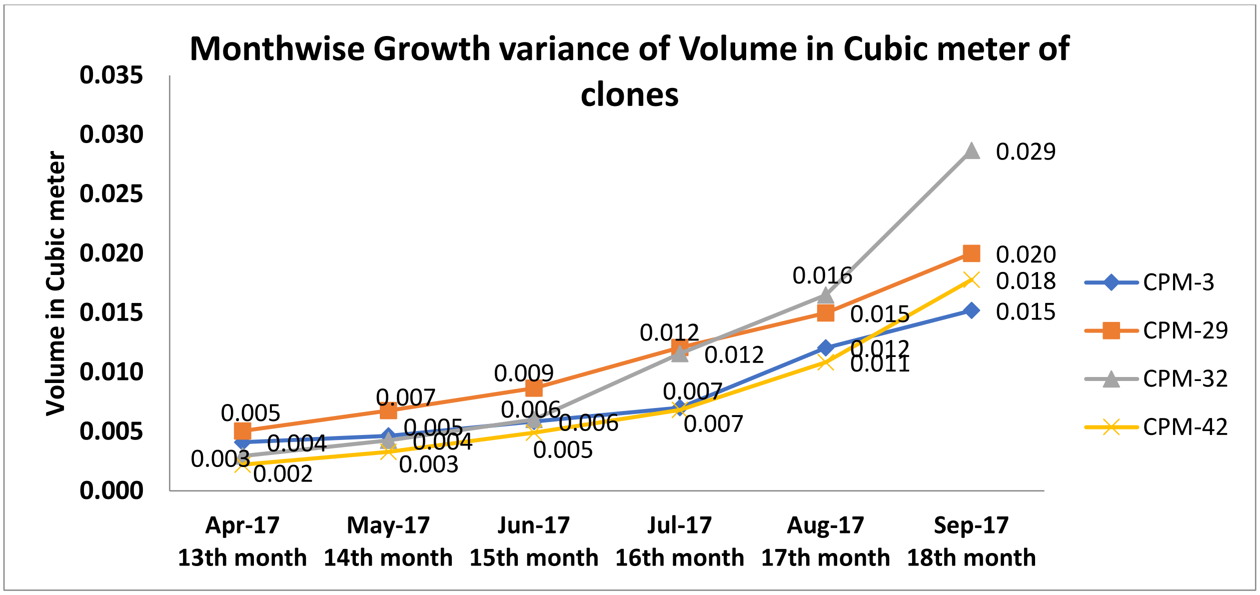

Fig. 7. Monthwise growth pattern of volume in cubic meter of subabul clones

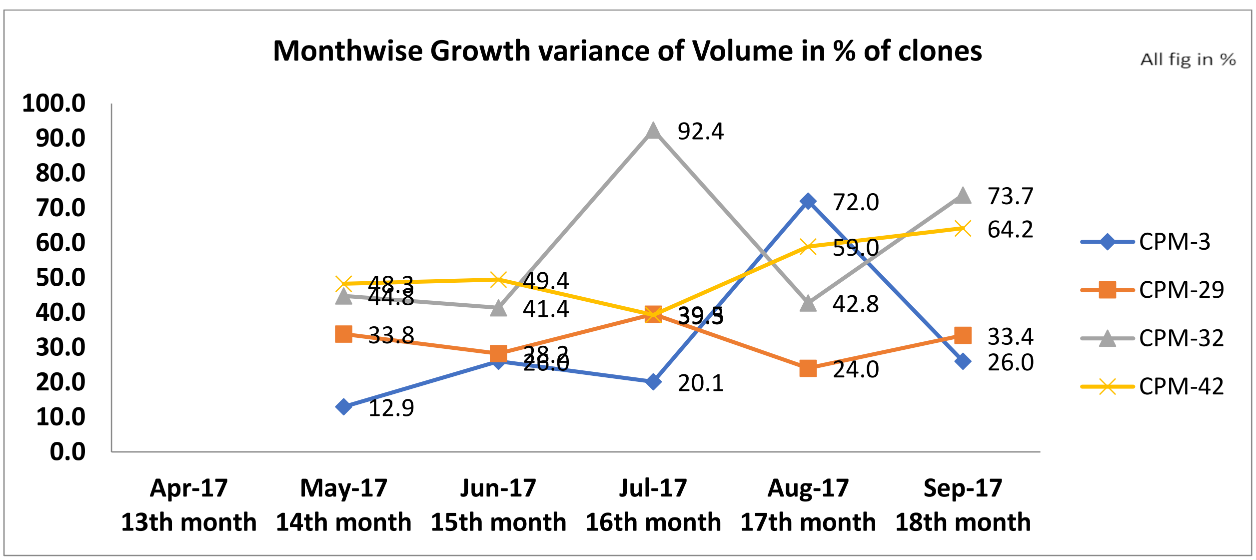

Fig. 8. Monthwise growth pattern of volume in % of subabul clones

Conclusion

Subabul, Leucaena, clonal programs have taken 'deep roots' among the farmers in Gujarat and Maharashtra States. This has increased wood production per unit area by 2–3 times compared with seed-planted plantations, thereby increasing net economic returns to the farmers. Clonal *Eucalyptus*, *Casuarina* and *Leucaena* plantations are making immense contributions towards development of wood-based industries, local asset value addition, employment generation, diversification of agriculture, greening of the country and environmental amelioration. Likewise, clonal technology, supported with an improved package of silvicultural management techniques and due safeguards, offers opportunities for substantial improvements in production of plantations and significant enhancement of quality of plantation-grown timber. Establishment of about 50,000 ha of plantations involving 66,000 farmers in areas surrounding the JK Paper Ltd, CPM unit mill has created a viable and sustainable economic model for farmers, transporters, paper mills and laborers. With these plantations, the CPM unit has developed a sustainable fiber resource to cater for raw material needs into the future. While substantial research advances have been made, much more needs to be done to increase productivity by mutation breeding, hybridization, selection and multiplication *in vivo* and *in vitro.*

References

Brewbaker JL 1988. Cloning of seedless Leucaenas for plantation use. *Leucaena Research Reports* **9**: 111-112.

Brewbaker JL, Wheeler RA and Sorensson CT 1988. Psyllid-tolerant highland leucaena yields. *Leucaena Research Reports* **9**:11-13.

IPMA 2023. website: http://ipmaindia.org/ (Accessed on Feb. 2023)

Lal P 2001. Private sector forestry research: a success story from India. *Bois ET Forests Des Tropiques*, 267(1): 33-48.

Sorensson CT 1988. Pollinating & emasculating techniques for Leucaena species. *Leucaena Research Reports* **9**:127-130.

Plate 1. Extension and Promotion for agro and clonal farm forestry plantation of Subabul *(Leucaena leucocephala)*

Plate 2. i) Mother cutting beds. ii) Cutting preparation process. iii) Cuttings in Mist chamber for rooting. iv) Rooted cuttings in Mist chamber. v) Subabul clonal plants in open nursery. vi) Land preparation for plantation. vii) 3 months old plantation in farmer land. viii) 14 months old plantation of subabul clone.

1.7/Lead Paper

Tree Census and Green Inventory – An Emerging Trend

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Introduction

Urban trees are an essential component of urban ecosystems, and management of this resource constitutes an essential element of urban open space management. Research has clearly shown the importance of urban trees for sustainable urban development through their capacity for delivering numerous important ecosystem services, which include: Provisioning services viz. fuel and food, regulating environmental services viz. storm water management, urban heat mitigation, air pollution regulation, cultural services like recreation, physical and mental health benefits and supporting habitat services like wildlife habitats (Grahn and Stigsdotter 2003; Tyrväinen et al. 2005; Gill et al. 2007; Jones 2008; Morgenroth et al. 2016; Dobbs et al. 2017).

Another concept gaining attention is ecosystem disservices, defined as functions or properties of ecosystems that are perceived as negative for human well-being and how management can affect the extent of ecosystem disservices caused by urban trees. Management of urban trees is key to sustaining and increasing important ecosystem services (Dobbs et al. 2017) and reducing the amount of ecosystem disservices (Lyytimäki 2017),

The concept of municipal tree inventories is the foundation on which management of urban trees is based. In recent decades there has therefore been increasing interest in municipal tree inventories, resulting from e.g. growing problems with pest and disease attack on the urban tree stock and growing awareness among decision-makers of the multiple ecosystem services trees provide in the cityscape. The relationship between tree inventory and green space budget may be a prerequisite for good tree management, while organisational aspects might also be important since there is an obvious need for an inventory if tree maintenance is outsourced. The execution of municipal tree inventories can be connected to factors such as size of the municipality, green space budget, or perceived need for the municipality to maintain a high number of urban trees and related records of tree removal and planting (Roman et al 2017).

Policy Background

There are many laws, rules and regulations formed to protect trees. Indian Forest Act, 1927 was introduced in India for the management and preservation of forest areas. Section 30 of the Act empowers the State Governments to issue notification reserving trees, etc. by notification in the Official Gazette. The **Forest Conservation Act, 1980** was also introduced to conserve forests and matters related to them. The Act protects forests, biodiversity, natural resources and heritage. This Act permits only unavoidable use of forest land for development purposes. The **Wildlife Protection Act, 1972** protects tree species and makes hunting and collecting such trees a criminal offence. These acts have given enough power to environment groups and residents to question authorities when trees are chopped indiscriminately to further development work or when they receive little care from the hands meant to serve them. The Tree census of urban and peri urban areas was first initiated during 2015 by Ministry of Environment and Forest, GOI, India for taking stock of the country's biodiversity and ensuring protection of its green areas. The census was also aimed at encouraging community awareness of the need for tree conservation, regulating pruning and felling and increasing green cover with people's participation.

Generally, extensive tree wealth exists outside continuous forested areas in every country. Termed as *Trees Outside Forests* (TOF), these are in the form of small woodlots and block plantations, trees along linear features, such as roads, canals bunds, etc. and scattered trees on farmlands, homesteads, community lands and urban areas. Traditionally, these were not inventoried and little quantitative information existed about TOF. However, lately a lot of interest has been generated worldwide on TOF. Besides providing support to rural economy, these trees are now a source of substantial forest produce in every country.

Forest Survey of India (FSI), an organization under Ministry of Environment & Forests (Government of India), is one of the few organizations in Asia that has been carrying out TOF assessments since the early 1990s. Assessment of Trees outside Forest for urban areas was made mandatory for all by implementation of Preservation of Trees Act by various States.

India's Forest area is 71.37 million hectares *i.e.*, 21.71% of the country's geographical area. However, the Tree cover is on 80.9 million hectares i.e. 24.62 % of the country's geographical area. Thus approximately 9.53 million hectares area under tree cover is outside forest area. India's State of Forest Report 2021 released in 2022 shows that there is a rising trend in India's growing stock, along with a rise in forest and tree cover by 2,261 square kilometres (sq km). Most of this spike has been due to an increase in area under Trees Outside Forests (Anon. 2021). Trees Outside Forest (TOF) are found in diverse formations in the rural and urban landscapes in the country like small woodlots, block plantations, trees along linear features such as roads, canals, bunds, etc. and scattered trees on farmlands, agricultural lands, homesteads, community lands and urban areas and non-forest landscape.

In view of The Maharashtra (Urban Areas) Preservation of Trees Act (1975) (Amended in 2010, 2012 and 2015), for better preservation, protection and plantation of trees on Urban areas, it is binding to the all-Municipal Corporation and councils to carry out a census of trees in all areas within the jurisdiction once before 1996 and thereafter once in every five years. According to Maharashtra (Urban Areas) Protection & Preservation Of Trees Act 1975 chapter four section 7 (b) once before December 1996 and thereafter once in every five years, carrying out a census of the existing trees in all land within its jurisdiction is mandatory. The tree census can serve as a potential platform for an environmental education program about the clean air, recharging of ground water, maintenance of biodiversity, reduction of noise pollution and so on. Action on legal - illegal tree cuttings can also be processed with the help of tree census data.

Tree census is defined as 'individual counted of the species and documentation of girth, height, canopy diameter, in addition of the species. These trees also count for the Trees Outside Forest and are included in the Tree Cover of the country. Historically, all along the human settlements planting of Trees is a common practice. Roads built centuries ago are existing with big, fruit-giving trees alongside, for the comfort and protection of people, are still the backbone of India's road map. Thus, the tree census will help to know the exact number of trees available at such locations.

The main objectives of the Tree census field inventory is to collect qualitative and quantitative information about the trees outside forest resources within precision limits in preparing reports to serve data needs of development planning. Some of the high-level scope includes:

- Geo tagging of all the trees under Census area / jurisdiction
- Query Search for trees by species, location, or advanced filters such as diameter, date planted, or tree characteristics, etc.
- Collection of Tree photos.
- Monitor the progress on green cover real time basis
- Get optional integrated tree key to assist in identifying tree species

According to the new amendment proposed by Maharashtra government to the Maharashtra (Urban Areas) Protection and Preservation of Trees Act of 1975, provisions will be added for the protection of ***'heritage trees'***. Under the proposed amendment, a tree with an estimated age of 50 years or more shall be defined as a heritage tree. Under this act the census count of Old trees will be possible and preservation of such trees will become mandatory. Methodology for determining heritage trees includes:

- Important native tree species.
- Trees having cultural/religious importance
- Tree species falling in the RET (Rare, endangered and Threatened) status.
- Tree species having an ecological importance/difficult to grow
- A large tree whose value is considerably irreplaceable.
- Tree associated with a historic person/event/landmark.
- Important forest tree species present within the existing landscape.

Objectives of Tree census

- Strengthen the enabling environment for the expansion of area under trees outside forests by increasing the resource base, certifying products derived from trees and regulating their trade to boost sustainable and equitable value chains, standardising quality planting material and aligning state and national policies.
- Expand the area under trees outside forests by incentivising and reducing risks for scaling up tree-based enterprises through establishment of business incubation and extension hubs, enhancing business support and financial services, improving access to quality planting material through high-tech, large and medium-scale nurseries, and creating Payment for Ecosystem Services (PES) schemes to establish and maintain ecological and economic tree species in mainstream farming systems and landscapes.
- Improve access to quality and actionable information about trees outside forests by enhancing the delivery of technical information and extension services for expanding the scale of trees outside forests and their related products, promoting access to technical and market-related information through a virtual call centre and online dashboard, promoting smartphone applications to inform technical decisions on the integration of trees into farming systems and landscapes, and carrying out solution-oriented research and outreach to accelerate expansion and impact in the targeted states.

Case Studies

Kane et al 2020 reported the Green Cover Analysis using Tree Census Data to Optimize the Biodiversity in Pune Municipal Development Area. study the scope and opportunities available in Pune to understand the temporal and spatial status of the green cover across the municipal limits that help improve the scenario in view of maintaining and optimizing the biodiversity. Tree Census & Inventory Report of Panvel Mega City for Wadhwa Construction & Infrastructure Ltd. was undertaken by Ecobasics Ecology Consultancy and Pvt. Ltd in 2013. Similar studies were conducted by Terracon EctoTech Pvt. Ltd. Mumbai for the assessment of GPS based Tree census for Thane Municipal Corporation and Pimpari-Chinchwad Municipal Corporation. Heritage Tree Census of Nashik Municipal Corporation. Similar Projects as required by the Maharashtra (Urban Areas) Protection and Preservation of Trees Act of 1975 are in the process in the State of Maharashtra.

Many States are in the process of Tree Outside Forest inventory and are undertaking tree census pin urban and peri urban areas. The states where the Tree census activities are being undertaken includes Karnataka, Tamil Nadu, Assam, Haryana, Gujarat, Madhya Pradesh, Delhi etc.

Tree Census Methodology

Tree census is carried out as per the guidelines issued by the FSI in *The Manual of Instructions for assessment of TOF*. (Anon.) The main objectives of the field census is to collect qualitative and quantitative information about the trees outside forest resources within precision limits in preparing reports to serve data needs of development planning. The data collection is carried out using census method, by which each and every individual tree was counted. The pioneer step is to develop a mobile application that can collect all required data pertaining to phenology, morphology and location of the trees. The census is also aimed at encouraging community awareness of the need for tree conservation, regulating pruning and felling and increasing green cover with people’s participation. Simultaneously, the data collected using mobile application is also synchronized with the web-based application. This helped in the transfer of collected data on the field directly from the mobile application to the main server. The manual takes into account almost all aspects involved in the inventory right from the start of the survey to the stage of final dispatch of data to the Zonal Head Quarters for data entry.

For tree census classification of towns, based on population is given, consists of six types of towns, but for this survey towns are classified for five types only as under:

Class-I : Towns having population of one lakh and above.

Class-II : Towns having population between 50,000 to 99,999.

Class-III : Towns having population between 20,000 to 49,999.
Class-IV : Towns having population between 10,000 to 19,999.
Class-V : Towns having population less than 10,000.

Field work in Tree census

For actual undertaking of survey and recording of census data filed crews are appointed. Each crew should complete inventory of two blocks on an average in one working day. Presuming the availability of minimum 20 working days in a month the monthly output should be above 40 blocks per crew. Considering availability of 9 months of fair weather season in a year the annual inventory work by a crew should be at least 40 x 9 i.e. 360 blocks. The annual turnover of the Zone will proportionately be expected on the basis of number of parties engaged on inventory work during different months of the year. After reaching the sample block crews next job is to identify the boundaries of the block given in the UFS map. For this purpose, the maps and local authority are to be consulted. Enumeration of trees commences from Northwest corner of the block and proceed in clockwise direction (i.e. north to east). The enumerated trees is required to be suitably marked to avoid duplication/omission of trees. During Tree census all trees having diameter ≥ 10 cms are recorded with reference to starting point/ reference point. The details of Data recorded in the survey census sheets is as given below:

1.	State code	Two-digit State code are to be used.
2	District code	Two-digit code will be used. The codes for districtsfalling in each state are pre-defined.
3	Town name	Name of the town will be written in this column
4	Town class code	Town class code will be recorded as under
5	Description of the Block with Boundries	The Block Identity with Boundaries are to be mentioned with reference to GIS Maps
6	Latitude	In six digits actual latitude of the starting point will be given in degree, minutes and second by using GPS
7.	Longitude	In six digits actual longitude of the starting point will be given in degree, minutes and second by using GPS
8.	Tree enumeration done by	

Field Survey Sheet

Sr. No.	Species Name	Local name	DBH	Height	Crown Width	Approx Age	Category of Plantation	Remarks

National Forest Inventory (Green Inventory)

The history of conducting forest inventory in India goes back to eighteen centuries. Assessment of the Forest Resource on a relatively large area basis (catchment basis) using statistically robust approach and aerial photographs began in 1965 when the Pre investment Survey of Forest Resources (PISFR) was launched in the country with FAO/UNDP assistance. As the forest inventories carried out in different parts of the country since 1965 were in a different time frame, it was not possible to generate national level estimates on growing stock, area statistics and other parameters with reference to one point of time. The cycle of TOF inventory has been decided to be 10 years. As is already known, TOF inventory has two parts 1) Rural and part 2) Urban. Different methodologies have been adopted using the same framework of 5kmx 5km grids for TOF (R) and TOF (U) inventory.

Sampling design for TOF inventory

The TOF area includes all areas outside the traditional/notified Reserved and Protected Forests but excludes notified rural or urban areas. As for any incomplete survey, sampling frame is required, sampling frame for rural and urban areas is prepared by Tree Authority headquarter using remote sensing and GIS technique. The sampling frame for TOF is obtained from the nation-wide uniform grid of 5 km x 5 km. The inventory cycle for TOF is taken as 10 years. Thus, all grids in the frame are numbered from 1 to 10. Within the selected grids for a particular year, two-phase sampling design is used. In the first phase, grids are stratified into block, linear and scattered stratum using high resolution remote sensing satellite data.

All the area grids are numbered from 1 to 10 for TOF inventory as well. For list of all urban towns and cities, census 2011 data have been used which has name and area. The latitude and longitude of centroid of all such towns are arrived at using BHUVAN and GOOGLE earth portal. Using the latitude and longitude of centroid and area of the towns, a buffer zone of appropriate radius is created. At state level, this layer of buffer area is considered as a proxy of digital urban area of that state. In a GIS framework, this urban layer is overlaid on the 5km x 5km grid layer. All such grids intersecting the urban buffer layer are considered as urban grid for TOF Urban inventory. All urban grids which are numbered 'one' are to be considered for 1st year TOF (Urban) inventory. On grid basis, towns are selected and Urban Frame Survey (UFS) blocks are randomly selected from these towns and are used for inventory. GPS device along with the Tree mapping software of Trimble could be used to take GPS positioning of each tree individuals and to caporal structural parameters. ArcGIS is a useful platform to create GIS based maps.

Statistical Inferences

The results of the Tree census survey would be acceptable with 15% permissible error at 95% probability level of confidence at district level. This accuracy is to be maintained and obtained for the entire physiographic zone. Sampling frame for Tree census in urban areas is prepared as per the guidelines of National Sample Survey Organisation (NSSO) under the Ministry of Statistics and Programme Implementation, Government of India. For inventory purpose the area is divided in blocks called UFS blocks. These blocks have clearcut well defined natural boundaries. These blocks are formed on the basis of 6000-8000 population or 1000-1500 households or demarked areas with roads, and cover the whole area within the geographical boundary of town including vacant lands.

The data collected from the Tree census could be subjected to statistical tests at a significance level of 0.05. To test the representativeness of the survey concerning spatial distribution of trees and municipal types, a Chi-square test could be performed on the observed distribution of responses between municipal groups as defined by the FSI Manual and compared with the actual distribution for the survey area. To test whether the responding municipalities differed in population size and area from National demographic census data of municipalities in general, one-sample Z-tests based on national statistics could be performed. As such, the responses to the survey helps in generation of representative maps with grid data having fair representation of area under study as a whole.

The data collected from the tree census inventory could be helpful in ecological analysis of the locality and calculate the IVI (Importance Value Index), Frequency and relative frequency of Tree species, Density and relative density of Tree population, Dominance and relative dominance of Trees, Simpson's biodiversity Index calculation and Classification of trees species by specific legislation (Rare, endangered, critically endangered, endemic and vulnerable).

Benefits of Tree Census

- ✓ The census is aimed at encouraging community awareness of the need for tree conservation, regulating pruning and felling and increasing green cover with people's participation. Tree census is one among those many steps as protection of existing green areas and trees at high priority area in Urban landscape.
- ✓ Aesthetics: Many native plants offer beautiful showy flowers, produce abundant colorful fruits and seeds, and brilliant seasonal changes in colors from the pale, thin greens of early spring, to the vibrant yellows and reds of autumn.

- ✓ Healthy Places for People: Lawns and the ubiquitous bark-mulched landscapes are notorious for requiring profuse amounts of artificial fertilizers and synthetic chemical pesticides and herbicides. The traditional suburban lawn, on average, has 10x more chemical pesticides per acre than farmland. By choosing native plants for your landscaping, you are not only helping wildlife, but you are creating a healthier place for yourself, your family, and your community.
- ✓ Helping the Climate: Landscaping with native plants can combat climate change. In addition to the reduced noise and carbon pollution from lawn mower exhaust, many native plants, especially long-living trees like oaks and maples, are effective at storing the greenhouse gas carbon dioxide.
- ✓ Conserving Water: Because native plants are adapted to local environmental conditions, they require far less water, saving time, money, and perhaps the most valuable natural resource, water.
- ✓ Wildlife: In addition to providing vital habitat for birds, many other species of wildlife benefits as well. The colorful array of butterflies and moths, including the iconic monarch, the swallowtails, tortoise shells, and beautiful blues, are all dependent on very specific native plant species.
- ✓ Ecological benefits: Native plants provide nectar for pollinators including hummingbirds, native bees, butterflies, moths, and bats. They provide protective shelter for many mammals. The native nuts, seeds, and fruits produced by these plants offer essential foods for all forms of wildlife.

Conclusion

The tree census is an important scientific, technical, and educational effort, which provides baseline data of urban areas on green cover of existing trees population. The results enable us to characterize the tree population in terms of its structure, function, and value. A tree census will also help in restoring lost green cover and calculating the carbon sink capacity. The existence of an inventory also increased the probability of the municipality having a tree management plan. Based on these results we recommend further research related to strategic management perspectives of tree inventories. The inventories are conducted by both consultants and in-house staff and the parameters they collect data on are primarily species, vitality, risk and DBH. The inventory data are primarily used for operational tasks, which might indicate the difficulty in moving from operational to the much wider and strategic ecosystem services approach. At present there are no guidelines describing how municipalities should work with this topic, and therefore, we foresee a future potential, but also a challenge municipal tree inventories for municipalities when, by law, they are expected to go from an operational to a more strategic management level.

References

Anita Kane, Viswanath Kumar Ganesan, Milind Sardesai, Mahesh Shindikar 2020. Green cover analysis using tree census data to optimize the biodiversity in Pune Municipal Development Area. https://ceur-ws.org/Vol-2557/paper-04.pdf

Anonymous 2021. India State of Forest Report (ISFR) 2021. Forest Survey of India, Ministry of Environment, Forest and Climate Change, New Delhi.

Anonymous 2021. Field manual on Assessment of Trees Outside Forest (Urban) (TOF-U). Forest Survey of India, Ministry of Environment and Forests, Kaulagarh Road, P. O: IPE, Dehradun, India.

Dobbs C, Martinez-Harms M-J and Kendal D 2017. The ecosystem services concept and its importance for socio-ecological systems, pp. 50-62. In: Rutledge handbook of urban forestry (2017) Ferrini, F., Konijnendijk van den Bosch, C. and Fini, A. (Ed.). Rutledge Taylor & Francis Group, London and New York.

Gill SE, Handley JF, Ennos AR and Pauleit S 2007. Adapting cities for climate change: the role of the green infrastructure. *Built Environ* 33(1):115–133. https://doi.org/10.2148/benv.33.1.115.

Grahn P and Stigsdotter AU 2003. Landscape planning and stress. *Urban for Urban Green* **2**(1):1–18. https://doi.org/10.1078/1618-8667-00019.

Jones N 2008. Approaches to urban forestry in the United Kingdom. In: Anderson B, Howart R, Walker L (eds). Ecology, planning, and Management of Urban Forests – international perspectives. Springer, Berlin, pp 109–117. https://doi.org/10.1007/978-0-387-71425-7_8

Lyytimäki 2017. Disservices of Urban Trees In: Rutledge Handbook of Urban Foresty (2017) Ferrini, F., Konijnendijk van den Bosch, C. and Fini, A. (Ed.). Rutledge Taylor & Francis Group, London and New York, pp. 164–175.

Morgenroth J, Östberg J, Konijnendijk van den Bosch C, Nielsen AB, Hauer R, Sjöman H, Chen W and Jansson M 2016. Urban tree diversity – taking stock and looking ahead. *Urban for Urban Green* **15**(1): 1–5.

Roman L, Scharenbroch B, Östberg J, Mueller L, Henning J, Koeser A, Sanders J, Betz D and Jordan R (2017). Data quality in citizen science municipal tree inventories. *Urban For Urban Green* **22**: 124-135.

Tyrväinen L, Mäkinen L and Schipperijn J 2005. Tools for mapping social values for urban woodlands and of other green spaces. *Landsc Urban Plan* **79**(1): 5–19.

1.8/Lead Paper

Forest Waste based Bioenergy Technologies for Livelihood, Soil Enrichment and Industries

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Introduction

Biomass is a renewable source of energy contains complex mix of carbon, nitrogen, hydrogen and oxygen. Biomass of this content is obtained from living or dead plants, by product of crop production, wood and agro based industry. Biomass energy consumption is in practice in India since ancient time. It is used in the form of cow dung cake, firewood, husk and many available natural feed stocks. However, direct use of biomass in solid form was not safe and painless as they produce lot of smoke and ash. Larger population of India lives in rural area. According to census 2011, 68.84% population of India lives in rural area. There are 0.638 millions villages in India, therefore to plan for electrification in villages; biomass will be vital option as a renewable source of energy. Ministry of New and Renewable Energy Sources (MNERS) has proposed to reach total 4324.22 MW of power generation based on biomass power and gasification as well as co-generation. MNRE, Govt. of India, has taken initiative like central financial assistance and fiscal incentives for promoting the use of bio-energy from agro residues, plantations and from various waste of urban and industries.

Available biomass resources in India

Biomass is defined as bio residue available by water-based vegetation, forest or organic waste, by product of crop production, agro or food industries waste. Various biomass resources are available in India in different form. They can be classified simply in the way they are available in nature as: grasses, woody plants, fruits, vegetables, manures and aquatic plants. Core distinct sources of biomass energy can be classified as residue of agricultural crop, energy plantation and municipal and industrial waste. Fig. 2 shows the various classification of biomass available in India. Forest biomass is an important supplier of fodder, feed and fuel. Fuelwood is the dominant biomass demand on forests, which also leads to biomass degradation. The estimated demand of fuel- wood in 1996 was 201 Mt, the increased requirement is estimated as 350 Mt yr−1 by 2025. As there is a net deficit in supply with respect to demand of forest biomass for meeting the various human needs, the forests in India are under pressure vis-à-vis what they can supply as a matter of sustained productivity. The forest biomass in addition also plays an important global environmental role. The quantity of biomass in a forest determines the potential amount of C (carbon) that can be added to the atmosphere or sequestered on the land when forests are managed for meeting emission targets. The mean biomass density in Indian forests was estimated as 135.6 t ha^{-1} and amongst the states it varied from 27.4 t ha-1 in Punjab to 251.8 t ha-1 in Jammu and Kashmir, respectively.

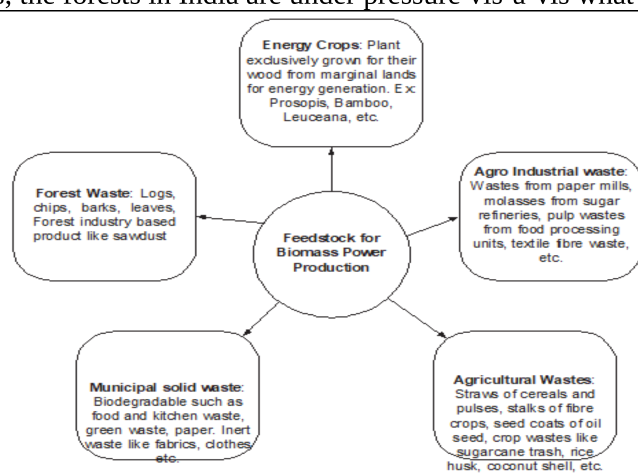


Fig. 2. Classification of available biomass resources in India.

Table 1. State and Union-territory wise forest area, above ground, below ground and total biomass in Indian forests

State=Union territory	Area (000 ha)	AGB[a] (Mt)	BGB[b] (Mt)	Total biomass (Mt)
Andhra Pradesh	4725.6	473.6	127.3	601.0
Arunachal Pradesh	6866.1	1014.2	260.8	1275.0
Assam	2450.8	382.5	97.3	479.8
Bihar	2658.7	184.7	51.6	236.3
Goa (Daman and Diu)	125.0	17.1	4.4	21.5
Gujarat	1204.4	110.8	30.1	140.9
Haryana	51.3	2.8	0.8	3.6
Himachal Pradesh	1250.2	231.8	57.8	289.6
Jammu & Kashmir	2044.3	413.4	101.3	514.7
Karnataka	3234.3	384.8	101.4	486.2
Kerala	1033.6	141.6	36.9	178.4
Madhya Pradesh	13539.6	1271.8	345.5	1617.3
Maharashtra	4385.9	383.4	104.5	488.0
Manipur	1762.1	150.4	40.7	191.1
Megahlaya	1576.9	134.3	36.0	170.3
Mizoram	1869.7	121.3	33.8	155.1
Nagaland	1434.8	149.0	39.8	188.9
Orissa	4714.5	425.7	115.9	541.7
Punjab	134.3	2.8	0.9	3.7
Rajasthan	1309.9	39.2	12.1	51.4
Sikkim	311.9	48.1	12.3	60.4
Tamil Nadu	1772.6	132.9	37.0	169.9
Tripura	553.8	31.2	8.8	40.0
Uttar Pradesh	3396.1	414.7	108.3	523.0
West Bengal	818.6	80.3	21.7	102.1
Andaman & Nicobar Islands	762.4	121.1	31.0	152.0
Dadra Nagar Haveli	20.6	1.6	0.4	2.0
INDIA	6865.1	1818.7	8683.7	64008.0

[a] AGB = above ground biomass; [b]BGB = below ground biomass.

Biomass energy conversion technologies

It is clear from the potential of biomass in India that various feedstocks are available for conversion to the bio-fuels as well as for power generation applications. The variety of processes exists for biomass conversions are depends on the type and quantity of biomass feedstock, environment and economic conditions etc. Conversion of biomass to energy is undertaken using two main process technologies: thermo-chemical and bio-chemical/biological. Mechanical extraction (with esterification) is the third technology for producing energy from biomass, e.g. rapeseed methyl ester (RME) bio-diesel. The thermal conversion processes consist of pyrolysis, biomass gasification, combustion and liquefaction.

Thermo-chemical conversion

Three main processes are used for the thermo-chemical con- version of biomass i.e. combustion, gasification and pyrolysis.

Combustion: Combustion is the burning of biomass in air, and it is used to convert the chemical energy stored in biomass into heat energy, mechanical power and also in electricity by different process and devices e.g. furnaces, stoves, steam turbines, boilers, etc. It is possible to burn any type of biomass but in practice

combustion is feasible only for biomass with a moisture content less than 50%, unless the biomass is pre-dried. High moisture content biomass is better suited to biological conversion processes .
The scale of combustion plant ranges from very small scale (e.g. for domestic heating) up to large-scale industrial plants in the range 100–3000 MW. Co-combustion of biomass in coal-fired power plants is an especially attractive option because of the high conversion efficiency of these plants.

Net bio-energy conversion efficiencies for biomass combustion power plants range from 20% to 40%. The higher efficiencies are obtained with systems over 100 MWe or when the biomass is co- combusted in coal-fired power plants. One heat engine cycle, the Stirling cycle, uses combustion to provide shaft power directly but the development of the cycle is presently limited to small power outputs.

Gasification: Gasification is the conversion of biomass into a combustible gas mixture by the partial oxidation of biomass at high temperatures, typically in the range 800–900 LC. The low calorific value (CV) gas produced can be burnt directly or used as a fuel for gas engines and gas turbines. The application of this produced gas can be used as a feedstock (syngas) for the production of chemicals like methanol.

One promising concept is the biomass integrated gasification/ combined cycle (BIG/CC), where gas turbines convert the gaseous fuel to electricity with a high overall conversion efficiency. An important advantage of BIG/CC systems is that the gas is cleaned before being combusted in the turbine, allowing more compact and less costly gas cleaning equipment to be used, as the volume of gas to be cleaned is reduced. The combination of gasification and combustion ensures high conversion efficiency, producing net efficiencies of 40–50% for a plant of 30–60 MWel capacity.

The produced syngas from biomass is used for the production of methanol and hydrogen, which can be considered as fuels for transportation and others. In the methanol production, either oxygen blown or hydrogen indirect gasification process are pre- ferred in production of methanol and the higher value CV gas (typically 9–11 MJ¼N m3) are produced by these processes.

Pyrolysis: Pyrolysis is the conversion of biomass to liquid (bio-oil or bio- crude), solid and gaseous fractions, by heating the biomass in the absence of air to around 500 LC. Pyrolysis can be used to produce bio-oil if flash pyrolysis is used, enabling the conversion of biomass to bio-crude with an efficiency of up to 80%. The bio-oil can be used in engines and turbines and its use as a feedstock for refineries is also being considered. But there are some problems which are still there to overcome such as corrosivity, less thermal stability. Upgrading bio-oils by lowering the oxygen content and removing alkalis by means of hydrogenation and catalytic cracking of the oil may be required for certain applications [40].

Bio-chemical conversion

Two main processes are used, fermentation and an-aerobic digestion, together with a lesser-used process based on mechanical extraction/chemical con-version.

Fermentation: Fermentation is used commercially on a large scale in various countries to produce ethanol from sugar crops (e.g. sugar cane, sugar beet) and starch crops (e.g. maize, wheat). The biomass is ground down and the starch converted by enzymes to sugars, with yeast then converting the sugars to ethanol. Purification of ethanol by distillation is an energy-concentrated step, with about 450 l of ethanol being produced by 1000 kg of dry corn. Solid residue obtained from this process can be given to cattle to feed and bagasse which is obtained from sugar cane can be used for next gasification or as a fuel for boilers.

The conversion of lignocellulosic biomass (such as wood and grasses) is more complex, due to the presence of longer-chain polysaccharide molecules and requires acid or enzymatic hydro- lysis before the resulting sugars can be fermented to ethanol. Such hydrolysis techniques are currently at the pre-pilot stage.

Anaerobic digestion: In Anaerobic digestion (AD) organic material is directly con- verted to a gas which is termed as biogas. It is a mixture of mainly methane and carbon dioxide with small quantities of other gases such as hydrogen sulphide. The biomass is converted in anaerobic environment by bacteria, which produces a gas with an energy of about 20–40% of the lower heating value of the feedstock. AD is a commercially proven technology and is widely used for treating high moisture content organic wastes, i.e., 80-90% moisture. Biogas can be used directly in spark ignition gas engine (s.i.g. e.) and gas turbines and can be upgraded to higher quality i.e., natural gas quality, by the removal of CO2. The overall conversion efficiency can be 21%. As with any power generation system using an internal combustion engine as the prime mover, waste heat from the engine oil and water-cooling systems and the exhaust could be recovered using a combined heat and power system.

Mechanical extraction: Extraction is a mechanical conversion process in which oil is produced from the seeds of various biomass crops such as ground- nuts, cotton, etc. The process produces not only oil but also a residual solid or 'cake', which is suitable for animal fodder. Three tons of rapeseed is required per ton of rape-seed oil produced.

Applications of Biomass Resources

The development of need-based biomass energy technologies is the first step toward the proper utilization of biomass at decentralized point. The development and propagation of biomass energy technologies in the rural area required proper assessment and characterization of biomass available in the local area. The different biomass technologies developed at DBSKKV, Dapoli were discussed in the paper with experimental results.

Biomass potential of Konkan Region

The assessment of biomass potential in Konkan region was carried out by categorizing the total biomass in three major groups as biomass from forest, biomass from culturable wasteland and biomass from agriculture and horticulture crop production. The total land under forest was further subdivided in two parts i.e., government forest and the un-culturable waste land (Table 3).

Table 3. Biomass producing area in Konkan region. (00,000 ha)

Sr. No.	Name of District	Geographical Area, (ha)	Biomass Producing area, ha	
			Forest	Un-cultivable
1	Grater Mumbai	0.38	0.015	0.073
2	Thane	9.337	4.464	0.566
3	Raigad	6.869	1.600	1.284
4	Ratnagiri	8.164	0.057	2.336
5	Sindhudurg	5.04	0.331	0.998
	Total	29.8	6.467	5.257

Characterization of biomass

The characterization of the biomass species from the different generation group was carried out by using the standard procedures. The most commonly available species from different sectors in a size of 5 cm X 15 cm was collected and characterized in the laboratory. The total 136 species were collected out of which 65 species were from the forest, 18 from un-culturable waste land, 38 from agriculture crop system and 15 from horticulture crop production. The various properties such as calorific value, moisture content, volatile matter, ash, fixed carbon and bulk density were determined. Out of 136 species identified, 65 species were selected for characterization. The characterized species include 26 from forest, 16 from un-culturable waste, 11 from agriculture crops and 12 species from horticulture crops. It was observed that, the moisture content of the biomass generated at the time of availability was 13%(wb). The average volatile matter content in the biomass was found to be 58%. The ash content and the fixed carbon content of the biomass were 10.93% and 17.20 % respectively. The most important component of the biomass to be considered while designing the biomass energy systems were bulk density (590 kg/m^3) and calorific value 4728 kcal/kg.

Assessment of Biomass and Bio-energy potential of Konkan region

The potential of biomass generation from the forest and un-culturable land in the Konkan region is summarized in Table2. The bio-energy potential of Konkan region considering the Utilization Recovery Factor (URF- 50%) is depicted in Table 4.

Table 4. Potential of biomass generation and Bio-energy potential of Konkan region

Sr. No.	Name of District	Biomass Potential, (00,000)		Biomass Potential (00,000)	Bio-energy Potential
		Tons/yea r (wb)	Tons/yea r (db)	Tons/year (URF-50%)	GJ/year
1	Grater Mumbai	1.936	0.968	0.484	871.2
2	Thane	110.66	55.33	27.665	49797
3	Raigad	63.448	31.724	15.862	28551.6
4	Ratnagiri	52.646	26.323	13.1615	23690.7
5	Sindhudurg	29.238	14.619	7.3095	13157.1
		257.928	128.964	64.482	116067.6

The biomass potential in the Konkan region from forest and un-culturable land was estimated to be 6.45 mmt. The bio-energy potential of Konkan region using forest and un-culturable land was estimated to be 116067 GJ/year.

Bio-energy technologies developed at DBSKKV, Dapoli

Down draft gasifier for thermal application

The down draft throat type gasifier with burner for thermal application (cooking) was installed and evaluated for its feasibility.

Gasifier :	Downdraft throat
Rated capacity :	25,000 kcal/h
Hopper capacity :	60 kg firewood
Rated gas output :	25 Nm^3/h
Fuel :	Wood chips
Bulk density :	>250 kg/m^3
Moisture content :	< 10%
Size :	25 – 100 mm
Biomass cons. Rate	8 – 10 kg/h
CV of gas :	1100 $kcal/Nm^3$
Biomass convert:	70 – 75 %
Biomass feeding :	Batch time 4 hours
Operating Period :	10 hours
Auxiliary load :	0.5 hp, 1 phase

The 25,000-kcal/h capacity downdraft gasifier system consumes on an average 10 kg of biomass per hour. The gasification process was found to be continues and constant quality gas was observed. The average air intake was found to be 18.79 Nm^3/hr, which generate the producer gas at the rate of 15.55 Nm^3/hr. The average calorific value of the producer gas found to be 1137 $kcal/m^3$. The overall gasification efficiency was found to be 51.43 % and biomass conversion efficiency was about 90.61%. The overall evaluation of gasification system revealed the suitability of acacia (*Prosopis juliflora*) wood as fuel and suitability of system for thermal application on the community cooking.

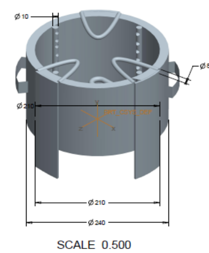
Open top gasifier for cooking

The study of existing biomass-based community cooking system was carried out at six different locations in and near the DBSKKV, Dapoli campus. The gasifier was designed, developed and evaluated at Ratnadurg (2) boy's hostel. The field testing of open top gasifier revealed the saving of about 22 per cent of fuel wood (*Acacia nilotica*) over the traditional cooking system. The economic evaluation of open top gasifier revealed that, the benefit-cost ratio and payback period was found to be 1.26 and 3.67 months, respectively and revealed its economic feasibility for cooking application.

Gasifier type	Open top	
Thermal Capacity	5 kW	
Outer diameter, m	0.29 m	
Reactor height, m	0.65 m	
Diameter of burner, m	0.23 m	
Fuel used	Wood Chips	
Operating period	2-2.5 hrs	
Fuel Consumption	1-1.5 kg/hr	
Thermal efficiency	23%	
Gasification efficiency	67%	

Biomass cook stove for household cooking

The improved biomass cooking stove was designed, developed and evaluated using different feed stocks such as CNS char, mango sticks, commercial briquettes and arecanut shells.

Cooking Stove	Household		
Diameter of combustion chamber, m	0.210		
Height of combustion chamber, m	0.150		
Area of combustion chamber, m^2	0.011		
Thermal efficiency, CNS char , %	31.21		
Mango Fuel wood,%	29.05		
Briqutted fuel, %	30.40		
Arecanut shell, %	28.95		

The thermal efficiency of the developed cooking stove was in the range of 29-31%. The stove was suitable for different type of fuel like CNS char, mango fuel wood sticks, briquettes and arecanut shells. CO/CO_2 ratios under emission testing were found to be 0.027, which is within the limit as per BIS.

Biomass briquetting technology

The screw extruded type biomass briquetting machine was developed and evaluated for the cashew nut shell and rice husk biomass materials in addition to dry dung and waste flour were as a ingredient.

			
A) Cashew nut shell	B) Rice husk	C) Dry dung	D) Waste flour (Binding material)

The capacity of briquetting machine was observed to be varying from 48 to 55 kg h^{-1}. The efficiency of the machine was found to be 95 per cent for various combinations of the briquettes. The best combination of the raw material (% cashew nut shell char, rice husk char, dry dung and waste flour) used for the production of briquettes was found as 55:8:27:10.

Briquetting Machine	Screw extruded type
Capacity	48-55 kg/h
Biomass	CNS, Rice husk, dung
Force, F	79.81 kN
Length of the belt, L	6.023 m
No. of screws	1
Diameter of screw shaft	30 mm
Diameter of screw	95 mm
Length of die	100 mm
Diameter of die	25 mm
Overall length of machine	2950 mm
Overall width of machine	2000 mm
Overall height of machine	1500 mm
Motor	2.23 kW (1440 rpm)

Biomass kiln for charcoal production

The biomass carbonization kiln to convert raw biomass into carboneous and smokeless charcoal was design and evaluated for different biomass.

Carbonization Kiln	200 lit.
Capacity of biomass	50 kg
Exit chimney, mm	950 L x 130 Ø
Top cover, mm	560 Ø
Carbonization chamber, mm	900 L x 550 Ø
Inlet air vent, mm (18 Nos)	33 L x 30 Ø
Exit door, mm	240 L x 233 Ø
Water inlet, mm	100 L x 400 Ø
Output charcoal	13.45 kg

The developed carbonization biomass kiln accommodated 50 – 60 kg of biomass per batch and carbonized the fuel in the period of 6 – 7 hours. The mass conversion efficiency, volumetric energy ratio and energy density ratio of charcoal production using *Acacia auriculiformis* were found to be 26.29 per cent, 1.88 and 1.70 per cent.

Biomass water heater cum dryer

The composite unit for water heating and reutilized flue gas-based dryer was designed, developed and evaluated to increase the overall thermal efficiency and efficient biomass utilization.

Biomass water heater	Shell and shell	
Type of fuel	Wood fuel	
Capacity, lit/h	27	
Diameter, cm	25	
Height, cm	61	
Outlet water temp.0C	60	
Drying chamber, cm	55×55×30	
Drying trays (2 Nos.)	500×500	
Capacity, kg	5-7 kg	

The overall efficiency of composite unit was estimated as 32.99 % during drying of nutmeg products and water heating. The increase in efficiency of composite unit (22.49 %) over thermal efficiency of water heater (30.75 %) revealed the advantage of reutilization of flue gases for drying application with liberation of cold flue gases (45.05 ºC) into atmosphere as compared to 300 ºC during single unit for water heating.

Biomass carbonization cum liquefaction unit

The flue gases liberated during the carbonization unit were condensed in the liquefaction unit and bio-oil and hot water were produced using the same biomass. The overall energy extraction from the biomass was increased using composite carbonization and liquefaction unit.

Carbonization Kiln	200 lit.	
Capacity of biomass	50 kg	
Operating period	5-6 h	
Output of carbonization	13.45 kg	
Liquefaction unit	Shell n Shell	
Bio-oil out put	2250 ml	
Hot water quantity, lit	200 lit	
Temperature of hot water	47.5 0C	

It was observed that, the total operating time required for carbonization of biomass was 5.5 to 6.5 hr. The combine carbonization and liquefaction of biomass, the final output was 13.45 kg charcoal, 1.5 kg fins, 0.34 kg charcoal powder and 2250 ml bio-oil along with hot water (47 degree centigrade).

References

Anil Kumar, Nitin Kumar, Prashant Baredar and Ashish Shukla 2015. A review on biomass energy resources, potential, conversion and policy in India. *Renewable and Sustainable Energy R*eviews **45:** 530–539

Anonymous 1999. Impact of NARP on income and employment generation in Konkan region report of Konkan Krishi Vidyapith, Dapoli, p. 37.

Anonymous 2001. Wood based energy system in rural industries and village application in India, Field Document No. 18: 1-9.

Chaudhari SR 1999. Short write – up on taluka-based biomass power plant" proceedings of business meet on Biomass combustion-based project, 28th Feb., 1999: 1-4.

Vimal OP and Tyagi PO 1992. Energy from biomass proceedings of AGRICOLE publishing academy: **39**.

Yadav YK 1995. Biomass gasification technique for agriculture proceedings of National bioenergy convention, Indian Institute of Technology, Delhi, 14-15 Dec., 1995, 78 pp.

1.9/Lead speaker

Natural Resource Management in Tree Based Land Use Systems: Soil and Water Conservation perspective

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Abstract: The biggest threat for survival of all life forms is changing climate which is the consequence of rising human population and unsatiated huger for more. Increasing frequency of extreme climatic events all over the world are clear indicators given by nature to the most intelligent specie to not to play with the natural resources, else large-scale devastation and destruction is a surety. Assessment of land use patterns using satellite imageries through various Remote Sensing & GIS platforms show unbiased story of spatial and temporal changes in land use patterns across the Indian subcontinent. To meet the demands of food and fodder for human and animal population as well to build the infrastructure facilities like townships, road, rail, industry, dams, canal network, etc are directly at the cost of vegetation and biodiversity. Deforestation, soil degradation, pollution, erosion, water scarcity is next in chain of events which are bound to cause misery to all life forms. On the other hand, there is lot of stress to produce more from per unit land and per drop of water, while there is already nutrient deficiency in our soils due to mono cropping, relay cropping in limited cultivable land. Afforestation for water conservation and erosion control, in addition to carbon sequestration, environment moderation are the additional benefits over and above the forest produce. The lecture discusses aspects of land use for conserving soil, water and vegetation, essentially required for long term sustenance.

Keywords: Land use planning, natural resources, afforestation, water conservation, sustainability

Natural Resources consists of soil, water, plants, and animals, that are exploited and manipulated by humans for its own benefits. Management of natural resources for survival of present and future generations is in the hands of human species. Rising human population is at the cost of land and other natural resources like soil, water, plant, and animals. In addition, human desire for consuming more is another factor which is impediment for sustainability. Vegetation / forest cover is the main factor which has paid the price of population growth and the so called "development" in last one and half century. The frequency of natural disasters and magnitude of devastation due to extreme climatic events are the indictors of climate change, globally. The paper discusses the status and changes in land use pattern with emphasis on soil, water and forest.

According to World Population Review, as on Jan 18, 2023, India's population stands at 1.423 billion surpassing China as most populous country of the world, it is about 17.7% of total world population and 18 % of cattle population. Due to improvements in healthcare facilities, there have been significant enhancements in infant and child mortality along with maternal mortality. All of these have contributed to the gains in the longevity in India and world. The life expectancy for India in 2022 is 70.19 years which is a 0.33% increase from 2021. In 1950, three years after the country gained independence, the life expectancy stood at 35.21 years.

The total geographic area of India is 32,87,263 sq. km. (TGA) which is 2.4% of worlds TGA, is the seventh largest country of the world having 9% area under land and 9% area under water, along with 7516.16 Km coastline. (Ref. : Geography of India, Wikipedia encyclopaedia.). India has, at present, 96.4 million hectares (Mha) of degraded land which is 29.3% of the country's total geographical area 328.7 Mha, out of this 264.5 Mha only is under agriculture, forestry, pasture, and other biomass production. The land area accounts for 7 – 8 % recorded species, including over 45968 plant species and 91, 364 animal species, which constitute 11.18 % of worlds flora and 7.44 % of worlds fauna. An ever-increasing human and cattle population have enormous demand on land resources which has its direct bearing on land utilization proportions on agricultural activities, forests, urbanization, industrial and infrastructure developments.

Soil degradation in India is estimated to be occurring on 147 Mhaof land, that includes 94 Mha from water erosion, 16 Mha from acidification, 14 Mha from flooding, 9 Mha from wind erosion, 6 Mha from salinity, and 7 Mha from a combination of factors (Kurrey*et.al.*, 2016).Among degraded lands, sodic soils are the most devastating abiotic stress faced by agricultural crops across the world (https://cssri.res.in/salt-affected-soils), which is around 6.74 million hectares. Gujarat, Uttar Pradesh, Madhya Pradesh, West Bengal, Maharashtra, Rajasthan, and Tamil Nadu cover the maximum salt affected lands. Soils having excess salt content negatively affects the growth, development, and production of most of the crop plants. On the global basis, the soil degradation is primarily caused by overgrazing (35%), agricultural activities (28 %), deforestation (30 %), and overexploitation of land to produce fuel wood (7%) and industrialization (4%) (http://www.globalchange.umich.edu/). Worldwide around 19.65 M Km^2 area is affected by human – induced soil degradation, mainly caused by water erosion (55.67%), wind erosion (27.94%), chemical degradation (12.16%), Physical degradation (4.22%), water erosion is the chief contributor of soil degradation worldwide (Oldeman, 1992). As per NBSS estimates extent of land degradation in India through water, wind erosion is 63.40 % and 6.42 % of the total degradation in India (Table 1).

Table 1. Types and extent of land degradation in India (Source: NBSS&LUP, 2010)

Type	Area (Mha)
Water erosion	93.68 (63.40 %)
Loss of top soil	83.31
Terrain deformation	10.37
Wind erosion	9.48 (6.42 %)
Loss of top soil	4.35
Terrain deformation / over blowing	5.13
Chemical deterioration	21.92 (14.83 %)
Salinization	5.89
Acid soils / loss of nutrients	16.03
Physical deterioration	14.29 (9.67 %)
Water logging	14.29
Others	8.38 (5.68 %)
Ice caps / rock outcrops / arid mountains	8.38
Total	147.75

Severity of soil erosion in India is classified by G Singh *et.al.* (1990), Table 2. They estimated that the average annual soil loss is about 15.2 tonnes per hectare and at national level it amounts to about 4978 million tonnes annually. The annual erosion rates vary from region to region. In dense forests covers, snow-clad cold deserts and arid regions of western Rajasthan the annual erosion rates are less than 5 tonnes per hectare. On the other hand, about 64 per cent of the total soil is contributed by highly to very severely eroded areas, such as the Shiwalik hills (annual rate is more than 80 tonnes per hectare), the Western Ghats, black and red soil regions, ravines and other gully eroded areas and the north-eastern region.

Table 2. Severity and soil loss due to erosion in India (Source: Gurmel Singh et al 1990)

Severity of erosion	Annual soil loss range	Share of the total affected area (%)	Annual loss of soil M. tonnes
Slight	<5	24	401
Medium	5-10	43	1406
High	10-20	24	1610
Very high	20-40	5	640
Severe	40-80	3	666
Very severe	>80	1	255
Total			4978

Land degradation is caused by multiple forces, including extreme weather conditions, particularly drought. It is also caused by human activities that pollute or degrade the quality of soils and land utility. Desertification is the consequence of land degradation which creates arid, semi-arid and dry sub-humid areas. It accelerates climate change which emanates into biodiversity loss, involuntary migration, wild fire, droughts, and emergence of zoonotic infectious diseases.India is focusing on sustainable land and resource management for livelihood generation at community level for making the local lands healthier and productive for providing a better homeland and a better future for its inhabitants.

- The National Action Programme for combating desertification was prepared in 2001 to take appropriate action in addressing the problems of desertification.
- Some of the major programmes which address issues related to land degradation and desertification, being implemented currently are as follows:
    - Integrated Watershed Management Programme (IWMP) (Pradhan Mantri Krishi Sinchayee Yojana)
    - National Afforestation Programme (NAP),
    - National Mission for Green India (GIM),
    - The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS),
    - Soil Conservation in the Catchment of River Valley Project,
    - National Watershed Development Project for Rainfed Areas (NWDPRA),
    - Fodder and Feed Development Scheme-component of Grassland Development including Grass Reserves.
    - Command Area Development and Water Management (CADWM) programme,
    - Soil Health Card Scheme, etc.

The Aravali range that separates western Thar desert from relatively green pains to its east has lost so much green cover that it is losing its ability to act as a natural barrier against the heat and dust that blows in from the west. To restore 26 million hectares of degraded land by 2030 and to check east ward march of that desert, government is planning to create 1400 km long and 5 km wide "**Green Wall**" from Porbandar Gujarat to Panipat Haryana, as a national priority, in lines with the "**Great Green Wall**" running through the width of Africa, from Dakar (Senegal) to Djibouti, to combat climate change and desertification. It will be a massive afforestation drive across degraded Aravali range, in which huge tract of land-degraded states shall be restored.

India receives nearly 4 per cent of the global precipitation and ranks 133 in the world in terms of water availability per person per annum. India receives around 1105 m (3880 BCM) of average rainfall. Generates a water potential of 1122 BCM with 690 BCM of surface water and 432 BCM of ground water. There is wide variation in rainfall distribution which varies from least in north west to the highest in north east which plays a major role in water availability among the river basins, Table 3. Since the amount of water available is constant, rising demands due to increasing population and economic growth will strain the demand–supply balance. The 2030 Water Resources Group (2009) estimates that if the current pattern of demand continues, about half of the demand for water will be unmet by 2030.

Table 3: Water resources of India (Source: Central Water Commission 2019-2020)

Average Annual Rainfall (1985-2015)	1105mm (3880BCM)
Annual rainfall (2018)	1074mm
Mean Annual Natural Runoff	1999.2 BCM
Total Utilisable Water	1122 BCM
Estimated Utilisable Surface Water Potential	690 BCM
Total Replenishable Ground Water Resources (2013)	432 BCM
Net Ground Water Availability (2013)	411 BCM
Ultimate Irrigation Potential	139.9 Mha
From Surface Water	76 Mha
From Ground Water	64 Mha

Storage Available Due to Completed Major & Medium Projects (Including Live Capacity less than 10 m. Cum)	253 BCM
Estimated additional Likely Live Storage Available due to Projects Under construction/ consideration	155 BCM

Climate change is impacting the water availability in various river basins in India is declining, Table 4, e.g. the annual per capita water availability declined from 1057 m^3 in 1991 to 848 m^3 in 2005, based on median yearly total water availability of 31.3Km^3. According to National Water Policy, the primary water allocation priority should be drinking water. River basin water resources have been used for irrigation, industry, navigation, drinking water, hydropower, and variety of local livelihoods (Mirza et al 2003). Manivannan et al (2022) states that blue print of irrigation and water conservation structures needs to deliberated, as due to climate change and melting of glaciers there could be increase in river flows due to melting of glaciers and the trend will reverse in the long term, high intensity rainfall events and temperature will have its own consequences. The peak discharge rate will be high resulting in frequent floods, hence necessary designs need to be adopted for protecting structures in addition to afforestation for conservation of soil and water.

Table 4. Details of river basins in India (Source: Jain et al 2007)

SL No	River Basins	Length (km)	Catchment area (km^2)	Average annual availability of water (km^2 a^{-1})
1.	Ganga	2525+	861,452+	525.02
2.	Indus	1114+	321,289+	73.31
3.	Brahmaputra	916+	194,413+	537.32
4.	Bark & other rivers flowing into Bark (Bark+)	-	41,273	48.36
5.	Luni and other west flowing rivers of Kutch and Saurashtra (Luni +)	371	-	15.10
6.	Sabarmati	583	24,674	3.81
7.	Mahi	1312	34,842	11.02
8.	Narmada	724	98,796	45.64
9.	Tapi	-	65,145	14.88
10.	West flowing river from Tapi to Tadri (WFR1)	-	-	87.41
11.	West flowing river from South to Tadri (WFR2)	-	-	113.53
12.	Brahmani, Baitarni&Subermarekha (BBS)	851	71,118	41.85
13.	Mahanadi	1465	141,589	66.88
14.	Godavari	1401	312,812	110.54
15.	Krishna	800	258,948	78.12
16.	Cauvery	597	81,155	21.36
17.	Pennar	-	55,213	6.32
18.	East flowing river between Mahanadi and Godavari (EFR 1)	-	-	22.52
19.	East flowing river between Godavari and Krishna (EFR2)	-	-	-
20.	East flowing river between Krishna and Pennar (EFR3)	-	-	-
21.	East flowing river between Pennar and Cauvery (EFR4)	-	-	16.46
22.	East flowing river south of Cauvery (EFR5)	-	-	-

Wetlands

Wetlands are regions where water plays a major role in regulating the surrounding ecosystem, along with the plant and animal life that it supports. They ae the biggest source of ground water recharge in addition to sustaining the ecology of the region. They usually develop where the water table is close to the land surface or where the land is submerged in water. They are characterized as "lands bridging terrestrial and aquatic eco-systems when the water table is typically at or near the surface or the land are covered by shallow water. On February 1st, 1982, India ratified the Ramsar convention to preserve and prevent Ramsar Sites. The Wetlands Rules 2017 permit notification of all wetlands, regardless of their location, size, ownership, biodiversity, or ecosystem services values, with the exception of river channels, paddy fields, man-made water bodies specifically built for drinking water, aquaculture, salt production, recreation, irrigation, and wetlands located in areas covered by the Indian Forest Act of 1927, the Forest (Conservation) Act of 1980, the Wildlife (Protection) Act of 1972, and the Coastal Regulation Zone 2011. Over 7 lakh wetlands, or 4.5% of the country's geographical area, exist in India, yet none of them have been recognized in accordance with domestic laws. The Wetlands (Conservation and Management) Rules, 2017, set forth regulations for wetlands. In India, there are 75 Ramsar Sites as of August 2022. The Ramsar sites are kept up-to-date in Montreux Record to monitor any significant ecological changes that could have a positive or negative impact on any of the wetland sites. As of now there is no specific legal framework for wetland conservation, management and their use in India. Currently, wetlands come under the Environment (Protection) Act, 1986 and other various legal instruments, related to environment and forests.

India has over 27000 wetlands of which over 23000 are inland wetlands while around 4000 are coastal wetlands. Wetlands occupy 18.4% of the country's area of which 70% are under paddy cultivation.Further, out of an estimated 4.1 m ha of wetlands, 1.5 m ha are natural, while 2.6 m ha are manmade. This implies that majority of the wetlands in India are Manmade.The coastal wetlands occupy an estimated 6,750 sq km, and are largely dominated by mangrove vegetation. On76th Independence Day, 2022, India designated 11 more wetlands under the Ramsar Convention or the Convention on Wetlands, taking the total number of Ramsar sites in India to 75 from 64. The largest wetland in India is the Sunderbans, which is also a part of the largest mangrove forest in the world. It consists of hundreds of islands, a maze of rivers, creeks nestled in the delta of the Ganga River and Brahmaputra on the Bay of Bengal in India and Bangladesh. The country has 19 types of wetlands, Gujarat has the maximum area followed by Andhra Pradesh, Uttar Pradesh, and West Bengal.

Rao and Balasubramanian (2021) Segregating the ecosystem services indicate that the annual value of indirect ecosystem services (sediment retention and eco-tourism) is usually thrice the estimates of direct provisioning services. The multiple benefits (both direct and indirect) provided by the Kuttanad wetlands to the different stakeholders implies the relevance of wetlands and hence highlights the necessity of conservation and management of Kuttanad wetlands for sustainable use in the future.

Lakes and pond

Farm ponds constructed in the natural depression of a farm land or village is a good option to conserve good quality rain water. The pond will not only store water for supplemental irrigation during *kharif* and *rabi* crops but also give fish harvest and could act as a sump to drain water from the fields in areas having high water table. In coastal areas having high water table, series of such ponds act a check against sea water ingress through sub surface flows.Also, these low points having waterlogged conditions in a watershed should be converted into scientifically designed ponds to raise sweet water fish, ducks, and other recreational activities. Shrivastava et al (2012) and Shrivastava et al (2015) reported improvement in ground water quality in wells by construction of ponds to conserve rain water and the benefits derived from such water bodies in a micro watershed.

Artificial recharge for coastal areas

In the coastal regions, due to overexploitation of ground water for domestic and agricultural use, the sea water ingress is observed resulting in deteriorated quality of water in aquifers. During monsoon, of high-water table conditions prevail in later part of monsoon as well as in periods of incessant rains,water does not infiltrate into the soil and create waterlogged conditions. There is a need to artificial recharge of ground water, at the time of initiation of monsoon water tables are deep, when good quality rain water is allowed to enter after desilting it in a pit, then sea water ingress could be pushed towards the seafrom the start of monsoon. In one such study at NAU, farmers were recommended to construct a percolation pit near their bore well, in the available natural depression / monsoon drain. The pit of size 4.0 m x 3.0 m x 2.0 m, along with 200 mm PVC strainer pipe, inserted before digging the pit up to first aquifer (about 12 m depth) for improving the ground water quality. The pipe should be about 0.6 m above ground with cap on top.

Waterlogging - Bio-drainage

To overcome water logged situations and utilize water stagnation situations, bio drainage is the most effective treatment for effective utilization of such waste lands. Bio-drainage relies on vegetation to remove excess soil water. It is found to be effective in specific situation like waterlogged landscapes, depressions and canal seepage interception and could be applied as an alternative to conventional field drainage system. A few trees such as *Eucalyptus* hybrid, *Dalbergi sissoo*, *Acacia auriculiformis*, *Albizzia lebbeck* can be used as bio drainage (Vivek Singh 2001). In most situations bio-drainage alone is not sufficient to control water logging and salinity, unless some form of engineering drainage is installed to provide salt balance by removal of saline drainage effluent. Bio drainage is an environment friendly, cheap and does not require highly technical design. It can give timber, fuel and fodder and improve micro climate. There have been several studies where bio drainage has been quite effective in controlling water table and enhancing salt leaching. It is useful where engineering measures are not cost effective, hydraulic conductivity is extremely low, gravity outlet is not available and ground water quality is a real problem for its reuse and safe disposal. Bio drainage is also useful in highly undulating terrain where levelling itself may be very expensive. Volume of water bio drained by Eucalyptus, when converted into depth of water table showed in first year was lowered by 2.28 m and in second year it lowered to 3.48 m, common rise in water table is 0.5 m/yr in most of the canal irrigated areas, Table 5. Besides bio drainage, other options include reducing irrigation water supply, reducing seepage from canal and management of water losses, improving irrigation efficiency, Vivek Singh 2001.

Table 5. Effective control of water table due to bio drainage by *Eucalyptus* plantation

Period of Growth	
12 months	2.28 m
12 to 24 months	3.48 m

Heuperman et al (2002) evaluated a bio drainage project examined an irrigated area of 18.2 ha with 4 ha of six-year-old eucalyptus trees planted at 1340 trees/ha. The surrounding area was planted to cotton, rice and sugarcane. The average water table depth under the eucalyptus ranged from 1.4 to 2.7 m and in the irrigated crop areas surrounding the plantation was 1.1 m to 2.1 m. Soil salinity remained below critical limits in the plantation. Water table draw down resulted in the groundwater moving as a front toward the eucalyptus plantation area and improved environmental conditions in the surrounding areas.

Temporary structures for soil and water conservation

- Ponds, Percolation tanks
- Terracing: Inward, Outward, Level; Graded
- Bunding
- Gully plugging
- Crop rotation
- Mulching
- Grassed Water way
- Diversion drains
- Surplusing arrangement

- Check dam: loose rock, poles, brush, earthen
    - woven wire, wooden planks
- Trenching: Graded, Contour, Staggered
- Land leveling
- Retaining walls
- Deep ploughing

Permanent Structures of Conserving water

- Drop spillway
- Drop inlet spillway
- Chute spillway

Watershed Management

Water management could also be achieved through selecting suitable farming activity commensurate with water availability that could meet the watering demand. It could also be selection of multiple crops in the same filed in various seasons as per the demand and supply of water. Such farming system will not only help in optimizing water resource but will also act as a cushion in case of failure of one crop. Mixed farming includes horticulture, forestry, floriculture, dairy farming, sweet water as well as saline water aquaculture, apiculture, goatry, etc. Area allocation to any of these types of farming could be the deciding factor as per the land use capability and water availability.

Forests for Conservation of Soil & Water

Forests are the most important eco system for conservation of water, the looming crisis of water scarcity and shortages is due to depleting vegetative cover and utter disregard to natural diversity resulting in extremes of climate that threaten the very survival of life on the earth. Afforestation could help in managing water resource in the form of infiltration through leaf litter added in the soil and facilitating water to seep into the ground through network of rooting system. Forest species do not require irrigation after getting established thus reducing the irrigation needs of the farm. If horticultural species are planted than they give better economic returns than cereal or pulse crop with minimum maintenance. Plantation of trees on farm periphery / boundary improves micro climate, acts as wind break, and reduces evaporation losses, thus improving water use efficiency of crops.

Forests are included in the Concurrent List in the (Seventh Schedule) of the Constitution of India.Through the 42nd Amendment Act, 1976 Forests and Protection of Wild Animals and Birds were transferred from State to Concurrent List.Article 51 A (g) of the Constitution states that it shall be the fundamental duty of every citizen to protect and improve the natural environment including forests and Wildlife.Article 48 A in the Directive Principles of State policy, mandates that the State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country.

The total forest cover in India (2023) is 7,13,789 square kilometres which is 21.71% of the total geographical area of the country. India added 1,540 sq km of forest cover from 2019 to 2021. The forest cover is divided into 3 parts.

- Very dense forest: All land with tree canopy density of 70% and above.
- Moderately dense forest: All land with tree canopy density of 40% – 70%.
- Open forest: All land with tree canopy density of 10% – 40%.

Very dense forest	99,779 sq km	3.04 % of India’s area
Moderately dense forest	3,06,890 sq km	9.33 % of India’s area
Open forest	3,07,120 sq km	9.34 % of India’s area
Total forest cover	7,13,789 sq km	21.71 % of India’s area

National Forest Policy

India's forests are currently governed by the National Forest Policy, 1988 which has environmental balance and livelihood at its centre.

- The percentage of the forest cover recommended by "National Forest Policy" is thirty-three per cent in plains and sixty-seven per cent in hills. The Indian "National Forest Policy" focuses on the importance of forests in maintaining ecological balance and environmental stability.
- The primary goal of the 1988 National Forest Policy is to preserve environmental stability and the maintenance of ecological balance, especially atmospheric equilibrium, which are essential for the survival of all life forms, humans, animals, and plants.
- A series of legislation aimed at improving environmental quality has been enacted in India.
- The Wildlife Protection Act of 1972, the Water Act of 1974, the Air Act of 1981, the Forest Conservation Act of 1980, and the Environment Protection Act of 1986 were all approved by the Indian Parliament.
- The consistent movement toward conservation, preservation, and protection was mirrored in forest management policies.
- As a result, the National Forest Policy was amended in 1988, with numerous revisions to the approach to forest management.
- As per Desertification and Land Degradation Atlas of India, 2016, 96.4 Mha is estimated to be under land degradation which accounts for 29.3% of TGA (SAC 2006).

Classifications of Forests

Based on Indian Constitution

1. State forests – cover about 94 % of total forest area (TFA)
2. Commercial forests – about 5% area of TFA, governed by local bodies such as municipalities, district boards
3. Private forests – constitute only 1% of TFA

On Administration-Basis

1. Reserved forests – constitute 53% of TFA under Government control, no public entry allowed for commercial purpose of cattle grazing
2. Protected forests - constitute 29 % of TFA under Government control, local people allowed to collect forest produce and cattle gathering without causing ay serious damage.
3. Unprotected forests – occupy only 18 % TFA, unclassified forests, no restrictions on cutting trees or grazing cattle.

Based on Composition and types of leaves

1. Conifers forests – temperate forests, grow in areas having low temperature. Vegetation comprises of core bearing needle leaved evergreen trees having downward sloping branches. About 6.5 % of TFA comes under coniferous forests
2. Broad leaf forests – are tropical and subtropical forests having vegetation with large leaves of various shapes, about 94 % of TFA of the country covers broad - leaf forests.

Based on Average Annual Rainfall

Ecosystems are the natural climax forests, resulting from a long process of ecological succession of plants and associated animals' life, undisturbed by man. The natural ecosystem that exists in India are as follows.

1. Tropical wet ever green forest
2. Tropical semi evergreen forest
3. Tropical moist deciduous forests (Southern and northern types)
4. Littoral and Swamp forests
5. Tropical dry deciduous forest
6. Tropical thorn forest
7. Tropical dry ever green forest
8. Sub-tropical broad leaved hill forest

9. Sub-tropical dry evergreen forest
10. Mountain wet temperate forest
11. Himalayan moist temperature forest
12. Sub alpine forest
13. Himalayan dry temperate forest
14. Sub alpine forest
15. Most alpine scrub
16. Dry alpine

Based on Merchantability

1. Merchantable forests: accessible, constitute 82 % of TFA of the county
2. Nonmerchantable forests:non-accessible, constitute 18 % of TFA of the county

National Commission of Agriculture (1976) proposed that forests can be classified into:

A. Protection Forests:

The practices of managing the forests for their protection function are called Protection forestry. In protection forestry, the object is to protect the site due to instability of terrain, nature of soil, geological formations, etc. Such areas where manipulation of the forest cover is not desirable may be classed as protection forests. The forests located on higher hill slopes, national parks and sanctuaries, preservation plots, biosphere or nature reserves and wilderness areas may be included under protection forests. The practice of forestry with a view to conserving flora, fauna, soil and water, increasing water yields, reducing floods and droughts, amelioration of climatic conditions, etc. is called Protection Forestry.

B. Production Forests:

The practice of forestry with object of producing maximum quantity of timber, fuel wood and other forest produce is called Production Forestry. The production forestry can be further classified into:

(i) Commercial Forestry: Commercial forestry aims to get maximum production of timber, fuel wood and other forest products as a business enterprise.

(ii) Industrial Forestry: Industrial forestry aims at producing raw material required for industry. In Production Forestry, there is a greater concern for the production and economic returns.

(iii) Mixed Quality Forests

(iv) Valuable Forests

(v) Inaccessible Forests

C. Social Forests: Social Forestry is the practice of forestry which aims at meeting the requirement of rural and urban population. The object of social forestry is to meet the basic needs of community aiming at bettering the conditions of living through:

(i) Meeting the fuel wood, fodder and small timber requirements
(ii) Protection of agricultural fields against wind
(iii) Meeting recreational needs and
(iv) Maximizing production and increasing farm returns

Various forms of social forestry:

a) **Community Forestry:** The practice of forestry on lands outside the conventional forest area for the benefit of local population has been called Community forestry. Community forestry seeks the involvement of community in the creation and management of such forests.

b) **Farm Forestry:** Farm Forestry is defined as the practice of forestry in all its aspect on farms of village lands generally integrated with other farm operations.

c) **Extension Forestry:** Extension forestry which includes the activity of raising trees on farm lands, villages wastelands and community forest areas and on lands along the sides of roads, canal banks and railway lines (Anon., 1976). More recently, there has been emphasis on dynamic land use planning and efforts are made to maximise production on farmlands under agroforestry.

d) **Agro-Forestry:** Agro-forestry has been defined as a sustainable land management system which increases the yield of the land, combines the production of crops and forest plants and/or animals simultaneously or sequentially on the same unit of land and applies management practices that are

compatible with the cultural practices of the local population.
e) Recreational Forestry: More recently, there has been considerable demand for Recreational forestry, which is defined as the practice of forestry with the object of developing and maintaining forests of high scenic value. Recreational forests are being developed near towns and cities. The areas are being planted with flowering trees, shrubs and creepers to provide forest atmosphere near towns and cities.

Chris Fowler and David Pedley (2013) report that in some catchments, there is clear evidence that plantation forestry can have an impact on water yield by intercepting rainfall and preventing it from entering rivers and streams. Given the increasing pressure on water supply for a range of uses and values, this is likely to result in further consideration of this issue in various regions throughout New Zealand. When considering potential regulation of new plantings, it is important that afforestation effects on water yield are not viewed in isolation. Any proposed regulation should also take into account the benefits of plantation forestry, the economic and environmental consequences of the proposed regulation, and the availability of other alternatives to achieve the desired objective.

Afforestation is effective soil erosion control measure, while enriching the soil organic matter, moisture and nutrients. Gurbachan Singh, 1990 reports an increase in organic carbon from 0.1 % to 0.08% in Jaisalmer and 0.22 % in Sriganganagar. Planting of suitable species like *Acacia tortilis*, *Acacia nilotica*, *Eucalyptus spp., Albizzia lebbek, Prosopisspp etc*. can grow and survive in the harsh geo – morphological conditionsand help in binding soil. The original soil properties were pH 10.2 to 10.51, EC 1.75 to 0.45dS/m, OC 0.12 to 0.24 %, available P 20 to 32 kg/ha and available K 12 to 310 kg/ha, (Table 6). It shows that afforestation of alkali soils with suitable species not only binds the soils but also shows improvement, there was many fold increase in soil organic carbon, while reclaiming the alkali soils to an extent that arable farming could be practiced on such lands, after felling trees on reaching maturity.

Table 6. Impact of few common species on soil enrichment (Age 20 Years)

Trees Species	Soil Depth (m)	pH	EC (ds/m)	OC (%)	Available P (Kg/ha)	Available K (Kg/ha)
Acacia nilotica	0-15	8.4	0.25	0.85	59.0	498.6
	0-120	9.0	0.53	0.55	33.9	298.3
Eucalyptus	0-15	8.5	0.44	0.66	33.3	358.9
	0-120	9.2	0.60	0.33	34.6	260.0
Albizzia lebbek	0-15	7.9	0.32	0.62	42.6	387.0
	0-120	8.7	0.51	0.47	44.2	225.6
Terminilia arjuna	0-15	7.9	0.32	0.86	67.8	409.8
	0-120	8.2	0.45	0.58	41.0	239.4
Prosopis juliflora	0-15	7.3	0.51	0.93	110.5	701.5
	0-120	8.0	0.41	0.58	50.1	330.0

(Source: Gurbachan Singh, Central Soil Salinity Research Institute, Karnal)

The research work carried out across the world revealed that tree plantation viz., *Prosopis juliflora, Acacia nilotica, Acacia auriculiformis, Casuarina equisetifolia, Tamarix articulata, Eucalyptus tereticornis, Eucalyptus hybrid, Leucaena leucocephala, Tamarixaphylla, Pongamia pinnata, Pithecellobium dulce, Albizia procera, Azadirachta indica, Acacia catechu, Terminalia arjuna and Dalbergia sissoo* found to be one of the viable options to ameliorate the sodic soils over a long period of time. These species improve the physical and chemical properties of surface soils owing to enhancement in the organic matter and nutrient cycling and pumping. Accumulation of OM and subsequent its decomposition processes improved the physico-chemical environment while, reducing the alkalinity and ESP on the exchange complex of the soils (Bhatt *et al* 2017). Dave *et.al.* (2021) studied the total tree diversity and estimated their related carbon inputs at the Legon Botanical Garden, Ghana University campus.

Conservation of Forests

- Coordination of various government departments
- Awareness amongst people for conserving forests
- Execution of policy guidelines for cutting of timber in forest / non forest areas
- Afforestation drives in PPP mode
- Regeneration of grass lands
- Strict implementation of Forest Conservation Act to check deforestation
- Recognition to people involved in forest conservation.

Generally, there are five agroforestry models prevalent in India i.e.agri-horticulture, agri-silviculture, agri- silvi-pastoral, pastoral-silviculture and pastoral-horticulture were prevalent in the area. The components of the dominant agroforestry system (AFS) practiced by the farmers are mainly woody perennials (forest and fruit trees) and agricultural crops (rice, vegetables, tobacco) with grass in fallow areas.

In India there are about 1,73,000 villages having more than 300 million people who largely depend on forest livelihood (MoEFCC 2018). With the aim to improve quality of forests as well as economic status of local communities, Joint Forest Management (JFM) was introduced in 1990, there are about 1,18,000 JFM committees catering to 20 million people. The major programmes launched in India to achieve the targeted aims of rehabilitate degraded forest lands are National Mission of Green India, National Green Highway mission, Twenty Point Programme, National Afforestation Programme, NamamiGange Programme, Forestry Intervention for Rejuvenation of Major Rivers. To achive these targeted goals, Colleges of Forestry are preparing trained manpower that could not only help in rehabilitating forests directly, but could also help in capacity building of state forests departments and tribal population. The specially trained man power meant for forestry in most states remains underutilized in the bureaucratic set of State Forest Departments.

Miyawaki Forests

Miyawaki technique developed by Japanese botanist Akira Miyawaki, in late 1970's, to grow dense forests of native plants is adopted all over the world, in India there are already hundreds of thousands of such forests across many cities. The natural forests that take more than 100 yrs to grow, is established in 2 to 3 yrs, after which it does not require much of maintenance and in 20 to 30 yrs it resembles natural forests. It is reported to be 30 times denser and develops 10 times quicker. Plant saplings of different native species are planted in layers, at approx. 60 cm spacing, according to their height, eg. Up to 3m, 4m, 8m and above. Bamboo sticks are used to train them for vertical growth, the plants are watered and fertilized initially for quicker growth. Barren lands along the coastal cities have the potential for developing Miyawaki forests which could be the barrier against tsunami threats in addition to providing clean air and improving the micro climate of cities. Under the Paris agreement, India has pledged to expand green cover from 25 to 33 % through adoption of such land use patterns which could be part of social forestry.

Mangrove Forest

Mangroves are salt-tolerant evergreen dense forests that grow in intertidal zones in tropical and subtropical estuarine regions and mud-flats. Additionally, mangrove forests provide many economical, ecological and environmental values to the people. According to state forest report of 2015 of Forest Survey of India, mangroves spread over 4,740 sq. km which is about 3 percent of world's mangrove vegetation and 0.14 per cent of the country's total geographical area. Mangroves are important means to control coastal erosion, also enhance sediment deposition which is essential to maintain their ecosystems. Several studies have been conducted using remote sensing and GIS which show that there is increased erosion rate in coastal areas where mangrove forests have died. Root architecture of mangroves is such that it traps sediments and prevents erosion from waves and storms. Mangrove forests also play an important role in many other edaphic functions which includes nutrient cycling, facilitation of plant nutrition, disease suppression, water purification, and biological attenuation of pollutants (Shedage and Shrivastava 2018).

Organic Carbon for Water Conservation

Soil carbon plays an important role in increasing soil fertility and improves water holding capacity of soil as well. In other words, improves water storage efficiency and ultimately increasing crop water use efficiency. Rawls et al (2003) found that at low organic carbon contents, the sensitivity of the water retention to changes in organic matter content was highest in sandy soils. Increase in organic matter content led to increase of water retention in sandy soils, and to a decrease in fine-textured soils. At high organic carbon values, all soils showed an increase in water retention. They observed the largest increase was in sandy and silty soils. Results were expressed as equations that can be used to evaluate effect of the carbon sequestration and management practices on soil hydraulic properties. Ghimire (2021) studied the carbon storage dynamics of different forest types in central, Nepal, he concludes that forest eco system plays an important role on carbon sequestration and sustainable management of such eco system is crucial to combat climate change.

The carbon sources help in regulating amount of greenhouse gases including water vapor, carbon di oxide, methane, nitrous oxide, ozone, and some artificial chemicals such as chlorofluorocarbons (CFC). The right amount of greenhouse gases in earth surface keeps it warm enough to all forms of life to exist. If greenhouse gas falls below then the earth's temperature will be too low to support flora and fauna, whereas, more concentration will make it warm to support all life forms. The key is balance between source and sink in the carbon cycle. The most important sinks are oceans, forests, and soil on land. The forests and oceans each remove around one fourth of the carbon than humans add to the atmosphere. During the last one and half century, the increased human activities particularly burning of fossil fuels, agriculture and deforestation are increasing the concentration of greenhouse gases. This enhanced greenhouse effect is contributing to warming of earth that is causing climate change. Forests could play an important role to mitigate the impacts of climate change. Forests are reservoir, sink and source of carbon, as it sequesters more carbon than any other terrestrial ecosystem. The diversity of forests in India makes it resilient to climate change and also an efficient sink of carbon.

The carbon stock for 2021 was estimated to be 7204.0 million tonnes (Table 7). There is an increase of 79.4 million tons of carbon stock as compared to the estimates of previous assessment. The annual increase of carbon stock is estimated 39.7 million tons which is 145.6 million tons of CO_2 equivalent. Soil organic carbon is the largest pool of forest carbon accounting for (55.67%) followed by AGB (32.20%), BGB (9.98%) and dead wood (0.66%) (Anonymous 2021). On comparing the changes between present and previous assessment, maximum changes have been observed in AGB and dead wood. The Forest Carbon Estimates at the national level under different carbon pools and change in respect to previous assessment is given in the following table.

Table 7. Forest carbon stock under different pools and changes with respect to previous assessment.

Component	Carbon Stock in Forest in 2021	Carbon Stock in Forest in 2019	Net change in Carbon stock	Annual change in Carbon stock
Above Ground Biomass	2319.9	2256.5	63.4	31.7
Below Ground Biomass	718.9	700.8	18.1	9.1
Dead wood	47.7	35.8	11.9	6.0
Litter	107.3	127.9	-20.6	-10.3
Soil	4010.2	4003.6	6.6	3.3
Total	7204.0	7124.6	79.4	39.7

Land Use Planning

Scientific planning of use of land is the pre requisite to high sustained outputs. The FAO Guidelines for Land-use Planning (FAO, 1993) defined land-use planning as:

Land-use planning is the systematic assessment of land and water potential, alternatives for land use and economic and social conditions in order to select and adopt the best land-use options. Its purpose is to select and put into practice those land uses that will best meet the needs of the people while safeguarding resources for the future. The driving force in planning is the need for change, the need for improved management or the need for a quite different pattern of land use dictated by changing circumstances. Land-use (or Land Resources) Planning is a systematic and iterative procedure carried out in order to create an enabling environment for sustainable development of land resources which meets people's needs and demands. It assesses the physical, socio-economic, institutional, and legal potentials and constraints with respect to an optimal and sustainable use of land resources, and empowers people to make decisions about how to allocate those resources.

Watershed and the land use are quite inter-dependent. Watersheds with a healthy aquatic system -in the form of adequate streams & wetlands, and an equally healthy biotic system -in the form of adequate flora and fauna, are generally sustainable systems. Watershed management is the process of formulation and carrying out a course of action involving the manipulation of natural, agricultural, and human resources in a watershed to provide goods and services that are desired by and suitable to the society, but under the condition that soil and water resources are not adversely affected. Watershed management must consider the social, economic and institution factors operating within and outside the watershed (Food and Agricultural Organization, FAO, cf. Gregersenk et al 1987). This is an integrated approach for production and utilization of natural resources

Types of land use systems in India

In India, the study of land utilisation is mainly based on the classification of land into the following categories:

1. Forests
2. Land put to agricultural use
3. Barren and wasteland
4. Land put to non-agricultural uses
5. Area under permanent pastures and grazing lands
6. Area under miscellaneous tree crops and groves (not covered in net sown area)
7. Culturable wasteland
8. Current fallow
9. Fallow other than current fallow
10. Net area sown

Assessment of Land Use Changes

Land use land cover (LULC) data play a central role in climate change assessment (Peter et al 2011). Remote sensing technology and geographic information system (GIS) provide efficient methods for analysis of land use issues and tools for land use planning and modelling. By understanding the driving forces of land use development in the past, managing the current situation with modern GIS tools, and modelling the future, one is able to develop plans for multiple uses of natural resources and nature conservation. To understand how LULC change affects and interact with global earth systems, information is needed on what changes occur, where and when they occur, the rate at which they occur, and the social and physical forces that drive those changes. The information needs for such a synthesis are diverse. Remote sensing has an important contribution to making and documenting the actual change in land use/land cover in regional and global scales.

Remote sensing data is the most common source for detection, quantification, and mapping of LULC patterns due to its repetitive data acquisition, suitable for processing, and accurate geo-referencing. Quantification of such changes is possible through GIS techniques even if the resultant spatial datasets are of different scales/ resolutions (Nayak et al 2017). Lakkad and Shrivastava (2016) used Remote Sensing and GIS techniques to estimate sediment yield and sediment delivery ratio for Dhaman Khadi Sub Watershed in Western India. They prioritized the micro watersheds for planning, execution, and management and to produce erosion susceptibility maps using ArcGIS interface and ArcSWAT model. The average erosivity for the period of 30 yrs for average rainfall of 1106mm was estimated to be 480.63 mt ha/cm, they also derived erosion susceptibility maps under 6 different classes for prioritization of conservation programmes. Bhanderi et al (2020) assessed the changes taking place in the land use pattern of nine micro watersheds near Dandi, located on the Arabian Sea coast, near Navsari city, using Remote Sensing and GIS facility and ground truthing from the selected micro watersheds. They characterized, identifying major problems, and prioritized with emphasis on ground water recharge to combat seas water intrusion, later, gave specific solutions to cope with the problems. The prioritization of micro watersheds could help the government to put investments in the order of its importance for the welfare of coastal communities. Nayak *et al* 2022 reports decrease in agricultural and forest areas, and increase in orchards and other vegetations, in most of the districts of South Gujarat, during 2000-2011. There is shift in forest area to Orchards and other vegetation, in Surat (18.25%) district there is major shift, could be due to avenue plantations, orchards and development of gardens. Forest area had decreased in almost all districts except in Bharuch. Barren land has increased in most of the districts which could be due to development of salinity and alkalinity levels along the sea coast, mining and increase of waste dumping sites and conversion of forest land into degraded forest lands. Built up areas has shown significant increase in the region confirming construction of new residential societies, road network, industry in the region, rising population, in the districts of South Gujarat. Kuntoji and Subbarayappa (2022) assessed the soil quality of rural and peri urban areas of Bengaluru, they found that most influenced indicators were OC, soil pH, S, P and clay, the soils of rural areas had SQI 0.61 and peri-urban 0.54 which falls under the medium category of soil quality 0.50-0.75. They concluded that the process of urbanization leads to shift in land use system, farmers instead of growing agriculture crops started growing commercial crops with injudicious use of fertilizers or dumping of fertilisers to get higher returns, resulting in soil degradation. Thakur et al (2022) assessed land use / land cover changes for the Wainganga in Godavari basin using RS & GIS technique. The change detection was done for the period of 34 years, 1985- 2019, they found significant changes during 2005-2019; before that, the changes were not very noticeable, the agricultural land shrunk while built-up expanded and variation in that period was 106% from the base period. Almost all evaluation studies done through remote sensing and GIS software's, on land use changes indicate fast changing land use dynamics resulting in warming and climate change.

Conclusion

In the back drop of rising population and visible climatic changes, there is an urgent need to take up concrete measures for preparing appropriate land use plans commensurate with the agro-climatic situation, for conserving soil, water, vegetation and biodiversity. Temporal changes in land use pattern observed through remotely sensed data and satellite imageries when analysed in various GIS software show the unbiased depiction of expanding urban, peri-urban and rural areas, encroaching upon agriculture and forest lands. Degraded land, soil erosion and pollution on the one hand and development of infrastructure facilities in the form of roads, rails, drains, electric and communication network are the other limiting factors to be kept in mind for any futuristic planning. Forest conservation and afforestation is one of the most important measures which should be given top most priority for sustaining soil, conserving water, mitigating the impact of climate extremes. Any land use plan must consider to preserve water bodies, rivers, wet lands, tree plantations for sustainable development.

Reference

Anonymous 2021.Carbon Stock in India's Forests. Indian State of Forest Report, 09: 194p

Bhanderi BN, Shrivastava PK, Dileswar Nayak and Patel DP 2020. Evaluation of Micro watershed of Coastal Navsari, *International Journal of Current Microbiology and Applied Sciences*, Special Issue **11**: 28-43

Bhatt H, Husain M, Rathore JP and Sah VK 2017. Bioremediation of problematic soils through Agroforestry practice. *J. pharmacogn. phytochem* **6**(5): 2044-2048.

Chris Fowler and David Pedley (2013), Managing the Impacts of Afforestation on Water Yield, The Canterbury Experience: 1-6.
Dave Mona, Vincent Von Vordzogbe and Henry NiiAmponsah 2021. Urban Tree Species Diversity and Related Carbon Contribution: A Case Study of the Legon Botanical Garden (LBG), University of Ghana Main Campus, *Indian Journal of Ecology* **48**(1): 243-251
Forest cover in India (2023) – important statisticshttps://geographyhost.com/forest-cover-in-india-important-statistics.
Ghimire Pramod 2021. Carbon Storage Dynamics of different Forest Types in Central, Nepal, *Indian Journal of Ecology* **48**(1): 196-203
Guidelines for land-use planning, FAO Development Series 1, ISSN 1020-0819, Food and Agriculture Organization of the United Nations, Prepared, by the, Soil Resources, Management and Conservation Service, under the guidance of the, Inter-Departmental Working Group on Land Use Planning, FOOD AND, AGRICULTURE ORGANIZATION OF THE UNITED NATIONS Rome, 1993
Gurmel Singh, Ram Babu, Narain P, Bhusan LS and Abrol IP 1990. Soil erosion rates in India, *Journal of Soil and Water Conservation* **47**(1): 97–99.
Heuperman Albertus F, Kapoor AS and Denecke Harry W 2002. Biodrainage: Principles, Experiences and Applications, International Programme for Technology and Research in Irrigation and Drainage, Food and Agriculture Organization of the United Nations, p. 79.
Jain SK, Agarwal PK and Singh V P 2007 Hydrology and Water Resources of India. Springer
Kuntoji Altaf and Subbarayappa CT 2022.Assessment of soil quality in rural and peri-urban areas of southern transect of Bengaluru by using Principal Component Analysis. *Indian Journal of Ecology* **49**(6): 2076-2081
Kurrey Dujeshwer, Singh RK and Rajput AS 2016. Status of soil erosion or land degradation in India, Managing Soil Resources for Environmental Sustainability: Challenges & Perspectives, Conference 9-10, Banaras Hindu University.
Lakkad AP and Shrivastava PK 2022. Use of ArcGIS Interface for Preparation of Erosion Susceptibility Map of Dhaman Khadi Sub Watershed in Western India, Managing Land Degradation for Enhancing Farm Productivity. P. R. Bhatnagar, D. Dinesh, Vijaysinha Kakade, V.C. Pande and Omprakash Meena (Eds), International Books & Periodical Supply Service, Delhi, 49-70.
Manivannan S, Kasthuri Thilagam V and Yaligar Ravindra 2022. Climate change impact on water resources in Indian river basins: a review. *Journal of Soil and Water Conservation* **21**(1):76-85.
Mirz MMQ, Warrick RA and Ericksen NJ 2002. The implications of climate change on floods of the Ganges Brahmaputra and Meghna rivers in Bangladesh, *Climate Change* 57: 287 – 318.
Nayak D, Surve N and Shrivastava PK 2017. Land use land cover changes using remote and GIS Technique: A Case study of Navsari District, Gujarat. *J of Tree Sci* **2**(36): 20-27.
Nayak Dileswar, NilamSurve and Shrivastava, Prashant Kumar 2022.Assessing Land use and Land cover Changes in South Gujarat, *Ecology Environment and Conservation* **28**(4): 2110- 2115.
Oldeman LR, Hakkeling RTA and Sombroek WG 1992. Worldwide map of the status of human induced oil degradation, ISRIC, Wageningen and UNEP, Nairobi, pp. 26.
Peter H, Verburg Kathleen N and Linda N 2011. Challenges in using land use land cover studies. *Glob Change Bio* **2**(17): 974-989.
Rao Sulakshana C and Balasubramanian R 2021. Segregating direct and indirect dimensions in ecosystem services valuation: The case of a coastal wetland ecosystem of South India, *Indian Journal of Ecology* **48**(1): 177-183.
Rawat Arun Singh 2020. Achieving zero net land degradation in Indian forest : prospects and Challenges, *Indian J of Soil Conservation* **48**(2): 120-124.
Rawls WJ, Pachepskyb YA, Ritchiea JC, Sobecki TM and Bloodworthc H 2003. Effect of soil organic carbon on soil water retention, *Geoderma* **116**: 61 – 76.
SAC 2016 Desertification and Land Degradation Atlas of India, Space Application Centre, Ahmedabad

Shedage Swati and Shrivastava PK 2018. Mangroves for Protection of Coastal Areas from High Tides, Cyclone and Tsunami. *International Journal of Plant & Soil Science* **23**(4): 1-11.

Shrivastava PK, Patel AM and Patel DP 2012. Rain Water Harvesting in Navsari Agricultural University Campus – a case Study, Full length Paper published in Proceedings of National Consultation Meeting on "Application Technologies for Harvested Rainwater in Ponds", organized by Central Research Institute for Dry land Agriculture (CRIDA), ICAR, Hyderabad, Mar.19 – 20, 2012.

Shrivastava PK, Surendra Kumar and Narendra Singh 2015. Evaluation of Benefits from Harvested Rain Water in Farm Ponds. *Indian Journal of Soil Conservation* **43**(3): 271-276.

Singh, Gurbachan 1990. Technology options for afforestation of salt affected sols of different regions, Central Soil Salinity Research Institute, Karnal.

Thakur Aradhana, Nema AK, Mishra PK and Seema 2022. Monitoring of Landuse /Landcover Changes for the Sub-Basin of Godavari Basin. *Indian Journal of Ecology* 49(6): 2260-2264.

Vivek Singh 2001. Land Resource Management in Western Rajasthan, Land Resource Management for Food and Environmental Security, Soil Conservation Society of India, New Delhi: 329 to 348.

1.10/ Lead Summary

Applications of Environmental Tracers in Water Resources Management

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Keywords: Water resources, groundwater, stable isotopes, environmental tracers, management

Environmental tracers are defined as geogenic (natural to the Earth) or anthropogenic (human-created) isotopes, elements, or compounds that are widely distributed in the near-surface environment of the earth, such that variations in their abundances can be used to infer environmental processes. Isotopes are a particular category of environmental tracers and are variants of chemical elements that have the same atomic number but differ in their mass number due to different numbers of neutrons in their nucleus. An ideal tracer of water flow is one that is soluble, mobile, relatively unreactive, and easily measured. However, while tracers that behave conservatively (that is, do not cling to subsurface materials nor undergo chemical change) in the environment yield information on water sources or transport processes, tracers that readily undergo chemical reactions can be used to determine hydro-chemical conditions in aquifers and reaction pathways. Several environmental tracers also provide information on the timescales of subsurface processes. These include radioactive tracers, which decay at a known rate; radiogenic tracers, which are produced and accumulate in the subsurface; and event markers, which are neither produced nor consumed in the subsurface but have a variable and well-known history as to when they entered the water system.

A large variety of environmental stable and radioactive isotopes are employed for hydrological studies (e.g., ^{2}H, ^{3}H, ^{3}He, ^{4}He, ^{6}Li, ^{11}B, ^{13}C, ^{14}C, ^{15}N, ^{18}O, ^{34}S, ^{36}Cl, ^{37}Cl, ^{81}Br, ^{81}Kr, ^{87}Sr, ^{129}I, ^{137}Cs ^{210}Pb etc.). However, the stable isotopes have the distinct advantage over injected (artificial) tracers (^{3}H, ^{46}Sc, ^{60}Co, ^{82}Br, ^{131}I, ^{198}Au, etc.) is that they facilitate the study of various hydrological processes on a much larger temporal and spatial scale through their natural distribution in a system. Earlier, artificially produced radioactive isotopes were being used with a very limited scope of their use as tracers only, but now environmental isotopes both radioactive and stable isotopes are widely used for a variety of applications with no fear of health hazards. Environmental isotopes are freely available in the atmosphere and automatically injected in to the hydrologic cycle. Therefore, the users have neither to purchase these isotopes nor to inject them in the hydrological system.

Application of isotope studies in surface water:

- Water Balance and Dynamics of Lakes and Reservoirs
- Seepage and Leakage from Water Bodies
- Discharge of Mountainous Rivers
- Sedimentation in Lakes / Reservoirs
- Soil Erosion from Watersheds/catchment
- Snowmelt Runoff and Hydrograph Separation
- Suspended and Bed Sediment Transport
- Sources and Tracing of Pollutants
- Paleo-hydrological Investigations

Application of isotope studies in groundwater:

- Soil moisture movement and variation
- Source identification
- Recharge zone identification
- Groundwater residence time
- Salinization (inland and coastal)
- Groundwater pollution

- Groundwater flow velocity
- Surface water-groundwater interaction
- Aquifer-aquifer interaction
- Sub-marine groundwater discharge
- Recharge estimations
- Recharge effectiveness

Application of isotope studies in environmental hydrology:

- Global and Regional Climate Change
- Sources of Precipitation and onset of Monsoon
- Contribution of Local Evapotranspiration in Precipitation
- ET partitioning
- Tracing out the Hydrological Cycle
- Altitude, Latitude, and Continental Effects on the Precipitation Regime
- Environmental Pollutants Tracing
- Global pattern of Mass Transfer in the Atmosphere

The starting point for interpreting environmental tracers is that transport is dominated by advection (transport of a substance by the bulk motion of the groundwater), rather than diffusion and dispersion. This assumption means that as the tracer moves along a flow line water gets progressively older. In groundwater studies, within a relatively homogeneous aquifer, it also means that water gets older with depth. There are, of course, several qualifications and exceptions to this general principle, but it provides a good starting point for us to think about the behavior of tracers

Types of Tracers

1. Tracers that provide information on the age of groundwater and that are principally used for determining water velocities and aquifer recharge rates. Types of tracers that fit into this group include radioactive tracers, radiogenic tracers and event markers.
2. Tracers that provide information on reaction processes and phase changes (e.g., evaporation, and condensation). Stable isotopes are one of the most important tracers in this group.
3. Tracers that are used for identifying water sources and groundwater flow and mixing. In addition to the tracers mentioned above, this group of tracers includes noble gases and ion concentrations.

Among the key challenges in water resources, isotopes can be used to address the following:

- Developing approaches to address the water problems of mega-cities
- Responding to the complex and deepening crisis of environmental pollution
- Contributing to understanding global climatic change
- Advancing professional sophistication in the practical application of isotope techniques
- Water resources and geothermal energy resources management
- Better understanding of hydrological process and better management of water resources
- To find out suitability of alternative sources of water for meeting out some specific demands such as in arsenic affected areas
- Addressing transboundary management issues

Do you know ground water moves much, much slower than river water, *i.e.,* groundwater – millimeter to meter/year; months to thousands of years old; river flow – meters/sec; even the largest rivers are renewed in a couple of weeks. If groundwater is “old”, the reservoir or aquifer is likely not being refilled!! *Have you ever thought about how old your drinking water is or where it came from? How would you figure out the answers to those questions if you wanted to know? Isotopes can provide the answer of these questions and may others about our water resources.*

1.11/Lead Summary

Transforming Livelihood of Tribal's through Processing and Value of Minor Fruits

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Keywords: Minor fruits, livelihood security, nutrition, tribal. Processing

Fruit trees like ber, aonla, jamun , tamarind , custard apple, bael, lasora, phalsa, ker, pilu, *etc* well suited for arid environment, remained under exploited owing particularly to lack of appreciation of their quality as fruits, their economic potential and above all due to non-availability of the needed technology for their profitable cultivation. Because of their curative properties, these fruits have been used in Indian system of medicine such as Ayurvedic and Unani since time immemorial. Apart from their nutritive and medicinal values quite a few of these underutilized fruits have excellent flavour and very attractive colour. In spite of these quality attributes most have not undergone any conscious phase of domestication and human selection. Their cultivation is very restricted and they grow mainly wild. Being tolerant to biotic and abiotic stresses, these fruit species are suitable for growing in the disaster- and drought-prone areas. India has a rich heritage of indigenous fruit types. Significant advances have been made in recent times towards providing technology support for their cultivation.

Processing and value addition in these minor fruits would provide employment, nutritional and economical security and these activities can easily be undertaken by tribal women. Several government agencies and NGOs have chosen fruits and their processing and value addition as an intervention for empowerment of tribal women and there are several success stories, which need to be replicated in similar situations/ locations. We at MPUAT Udaipur, Rajasthan along with an NGO and private partners have demonstrated that how custard apple and jamun processing has transformed the life of tribals and provided lots of entrepreneurship/ employment opportunities at doorstep.

1.12/Lead Summary

Potential of Homegardens for Carbon Market in Sub Himalayan Region of West Bengal, India

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Keywords: Homegarden, carbon sequestration, REDD+, soil organic carbon

Homegardens the oldest agroforestry systems are rich repositories of agro- and wild biodiversity with roles of providing various ecosystem, social and cultural services along with sustaining livelihood of rural and indigenous communities. Agroforestry systems play a vital role for reducing emissions from deforestation and forest degradation (REDD+) programs and thus is recognized as viable carbon sequestration strategy under the afforestation and reforestation (A and R) activities of the Kyoto Protocol. Unfortunately, very fewer studies were conducted on carbon sequestration in homegarden agroforestry systems. Studies have shown that trees in the agricultural landscapes often improve the productivity of systems while providing opportunities to create C sinks and have higher carbon storage potential than any other land uses in agricultural landscape. The potential seems to be substantial but has not been even adequately recognized, let alone exploited. One of the important land use features of Terai region in West Bengal is homestead agroforestry systems as every households has a homegarden. Though homegardens of the region was reported to be repository of biodiversity and storehouse of biomass carbon but no attempt was found reporting the potential of carbon market in the region sequestered by these homegardens. The carbon storage potential of these homegarden agroforestry systems needs to be assessed in terms of the monetary values for the benefit to the farming communities of the region for improving their livelihood.

The study was conducted at the forest villages of Buxa Tiger Reserve (BTR) in Terai zone of West Bengal, India. The homegardens were very small with an average area of 0.0112 ha. *Areca catechu* a palm was prominently found in the homegardens due to its small canopy and commercial value. Overall average woody biomass, woody biomass carbon, SOC (up to 60 cm soil depth), ecosystem carbon, carbon offset and offset value for the sampled homegardens estimated was 4.83 Mg, 2.40 Mg, 0.74 Mg, 3.15 Mg, 11.52 Mg CO_{2e} and 28.8 US $, respectively, of which palms contributed 66.19 % of the total woody biomass. Palms were responsible for more than three fourth of the homegarden biomass variability and thus also significantly influenced the carbon sequestered, offset and value of the offset. Significant positive relationships were also observed among the number of palms, palm biomass, total homegarden biomass and carbon, carbon offset and offset value. The homegardens in the studied villages also varied significantly in their ability to offset carbon but due to significant variation in number of trees. This indicates difference in cause of variability at landscape level i.e. at micro-landscape or homegarden level variation was due to palms, while at macro-landscape or village level trees caused variation. The information generated is base line and can be vital for institutional intervention to initiate biocarbon projects in the region linking the poor communities with carbon trade. However, these needs empowering the livelihoods with capacity building and improved productivity particularly the palm *Areca catechu* which will attract these communities towards international carbon trade, while improving their resiliency and making them partners in global efforts of climate change mitigation.

1.13/Lead Summary

Forest Burn Effects on Pine Forests of the Southern United States

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Keywords: Forest fire, coniferous forest, species diversity, Phospholipid Fatty Acid Analysis,

Forest fires, intentional or accidental, affect forest ecosystems in myriad ways, including their effects on stand dynamics and composition, understory and overstory diversity, soil properties, microbial communities, and several other forest and ecosystem attributes. Both frequency and season of burn may affect these attributes differently. Our multiple studies evaluated short and long-term effects of fire frequency as well as season on different pine species of the southern United States. While longleaf pine is a fire-resistant species, slash pine is vulnerable to fire, particularly in younger stage. Both species may regenerate satisfactorily with inclusion of periodic burning in their silvicultural regimes. Our results showed that burned forest stands exhibited higher species diversity in the understory, though season of burn has minimal impact. Soil properties, including pH, organic matter (%), total N (%), total C (%), cation exchange capacity, Ca, Mg, K, etc. are significantly different in the no burn control compared to seasonally burned treatments. However, P concentration did not differ significantly between burned and unburned treatments. While burning caused significant changes in most soil properties, season of burning itself rarely showed significant effects. Total microbial biomass, including bacterial and fungal biomass, as estimated using PFLA (Phospholipid Fatty Acid Analysis) concentrations, were largely similar between no burn (3,129.17 ng/g soil) and the three burn season treatments (2,354.22 to 3,810.10 ng/g soil). Seasonal burning did not have a substantial effect on bacterial composition or diversity at phylum, family, or operational taxonomic units (OTUs) levels, identified using next generation sequencing (NGS). This suggests that microbial communities are resilient to long-term repeated seasonal burning. Broadly, our multiple studies have shown that burning significantly changes forest characteristics compared to unburned forests, though the season of the burn is significant only for select attributes. We will discuss our research results and their implication for southern pine management.

2.1/T_2-03

Carbon Storage Potential of an Agricultural-Forest Landscape: A Novel Approach Towards Climate Change Mitigation

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Keywords: *Gmelina* spp., biomass, Co_2 emission, carbon sequestration, soil carbon

1. Introduction

Climate change is a global concern now and Trees outside Forests in agricultural landscapes are an effective strategy to offset terrestrial CO_2 emissions. *Gmelina* spp. farm forestry plantations are dominant in the Terai region of West Bengal and the potential of these plantations needs to be analysed for their capability to produce biomass and store carbon for a longer duration as a viable avoided emission strategy.

2. Materials and methods

The present work was conducted from September 2018 to February 2020 in randomly selected *Gmelina* spp. farm forestry young unmanaged plantations. The non-destructive method using allometric equations was adopted for above-ground biomass (AGB) estimation of the trees. Below-ground biomass was estimated as 15 % of the AGB and the total tree biomass was converted into carbon by multiplying with a factor of 0.50. Soil organic carbon stock was estimated by multiplying the organic carbon with the weight of the soil (bulk density and depth) for a particular depth and expressed as Mg ha^{-1}.

3. Results and discussion

Total biomass density and carbon density increased with increasing plantation age while no drastic variation was found in available soil organic carbon (SOC) because of insignificant variability in litter production. Total carbon, available SOC (up to 60 cm depth) and ecosystem carbon in the three age class plantations fell in the ranges of 54.51–59.91, 48.18–55.73, and 104.81–110.77 Mg ha^{-1}, respectively. Similar quantification of biomass accumulation and carbon storage in eucalyptus plantations was also reported by Kumar et al (2020). Quantification of biomass in tree plantations at agricultural landscapes will aid in formulating sustainable management strategies for increasing carbon pool build-up outside forest land use.

Reference

Kumar P, Mishra A K, Chaudhari S K, Sharma D K, Rai A K, Singh K, Rai P and Singh R. 2020. Carbon sequestration and soil carbon build-up under Eucalyptus plantation in semi-arid regions of north-west India. *J. Sustain. Forestry* **40**(4): 319-331.

2.2/T_2-04

Floristic Diversity and Carbon Storage of *Tectona grandis* Linn. F. Plantation in Agricultural Landscapes of Terai Zone of West Bengal

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Keywords: Diversity, Teak, biomass carbon, soil carbon

1. Introduction

The potential of Trees outside Forests to store large quantities of carbon needs to be assessed and monitored properly for which local, regional or national inventory is required (Pandey et al 2010). Many studies on the quantification of understory vegetation diversity, biomass and carbon storage potentials of various tree species have been carried out, but studies on Teak in agricultural landscapes in the sub-Himalayan region are lacking.

2. Materials and methods

The present work was conducted from September 2018 to February 2020 in randomly selected young unmanaged teak farm forestry plantations categorized into ≤ 5, 5-10 and 10-15 years age classes. In a plantation, 10 % of the teak trees were randomly selected, while all other trees other than teak were selected. A stratified random nested quadrat sampling method was adopted for analysing other vegetation forms within a plantation. Ecosystem carbon storage is estimated by the summation of biomass, soil, and litter carbon present in the system.

3. Results and discussion

Overall species richness of the plantations was 28, of which 11 were trees, 9 herbs, 3 each of shrubs and climbers and 2 ferns. Based on IVI values, herbs were the most important species followed by shrubs and trees. With the increasing age of the plantation, the richness of plant species decreased and so were the vegetative parameters and diversity indices. Soil physicochemical properties were significantly influenced by the plantation age but exhibited no discreet trend. Total biomass density and carbon density increased with increasing plantation age while no drastic variation was observed for available SOC as litter production did not vary much with increasing plantation age. The overall mean total plant biomass, total available SOC and ecosystem carbon in the plantations was 83.1, 39.63 and 81.18 Mg ha^{-1}, respectively.

Reference

Pandey U, Kushwaha S P S, Kachhwaha T S, Kunwar P and Dadhwal V K. 2010. Potential of Envi sat ASAR data for woody biomass assessment. *Tropical Ecology* **51**: 117-124.

2.3/T_2-05

Dynamics of Agroforestry Landscape using Geospatial Techniques and Field Survey–A Case Study in Central Western Ghats, India

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Keywords: Agroforestry, dynamics, land cover fraction, land use

1. Introduction

Assessment of land cover land use change (LCLU) in Central Western Ghats, India is essential to evaluate the ecosystem degradation and its environmental processes caused due to climatic and anthropogenic pressures. Despite knowledge of numerous dimensions between biodiversity loss and human wellbeing, the species are continuing to disappear at an alarming rate. Thus, it becomes imperative to develop a comprehensive understanding of each land use trajectories by delineating and estimating the area under agroforestry, and understanding the factors influencing the land use change.

2. Material and methods

The Google Earth Engine was used to perform image collection, supervised classification and accuracy assessment using machine learning algorithm. The Sentinel-2b data was used to delineate the area (10 m resolution) for 2021 while the change in land cover land use trajectories were studied using Landsat-5 (2001) and Landsat-8 (2021) surface reflectance images with 30 m spatial resolution. The eight thematic classes used in the classification were 1. Agroforest 2. Cropland 3. Built-up 4. Waterbody 5. Dense Forest 6. Open forest 7. Plantation Forest and 8. Barren land. The accuracy assessment was made through a confusion matrix to calculate the Kappa index and overall user and producer's accuracy. Finally, the LULC change graph were elaborated and calculated.

3. Results and discussion

The Uttara Kannada district in Central Western Ghats, known for its historical species diversity covers an area of 692631 hectares of dense forest followed by open forest constituting 125792 hectares of the total 1049100 hectares area. Area under cropland constitutes 119573 hectares where sowing of paddy is the major agriculture practice followed by sowing of Maize, Jowar, Ragi and Sugarcane by farmers in Uttara Kannada district of Central Western Ghats.

Table 1. Change in land cover fraction over past two decades (2001-2021) using Landsat 5 & Landsat 8 in Central Western Ghats

Land Use	2001		2021		Change in Area	
	Area (ha)	Per cent	Area (ha)	Per cent	Area (ha)	Per cent
Agroforestry	14374	1.38	25758	2.47	11384	1.09
Cropland	106841	10.25	120379	11.55	13538	1.30
Built-up	18020	1.73	32670	3.14	14650	1.41
Waterbody	24390	2.34	26593	2.55	2203	0.21
Dense Forest	765496	73.47	691124	66.33	-74372	-7.14
Open Forest	90732	8.71	124273	11.93	33541	3.22
Plantation Forest	10446	1.00	12926	1.24	2480	0.24
Barren land	11611	1.11	8187	0.78	-3435	-0.33
Total Area (ha)	1041910	100	1041910	100		

Area under agroforest class was analyzed to be 24965 hectares that chiefly comprised Arecanut based plantation crop combination followed by diverse species home gardens, tropical fruit tree orchards (mainly mango, banana cashew and coconut), commercial timber block plantations (majorly Teak, Mahogany, Red Sanders) *etc*. Waterbody constituted an area of 26518 hectares while 13138 hectare of total land area was covered under built-up due to increasing family fragmentation and population demand. *Tectona grandis* and *Acacia mangium* dominated plantation forest raised by

Karnataka Forest Department constituted an area of 12729 hectare while barren lands towards West Coast/ patches with no vegetation comprised an area of 8345 hectares.

Failure in monitoring of dense forest cover deforestation in Central Western Ghats has resulted in decrease of 73.47 per cent of thick dense vegetation in the year 2001 to 66.33 percent area in 2021. The resultant decline in area of -74372 hectare is due to massive deforestation (especially in regions of Eastern Plains), encroached agriculture and Arecanut based plantation establishment in the valleys, increase of clustered settlements and infrastructural projects in the region.

References

Floreano IX and Moraes LAF 2021. Land use/land cover analysis (2009-2019) with google earth engine and 2030 prediction using Markov-ca in the Rondonia state, Brazil. *Environment Monitoring and Assessment* **2021**: 193-239.

Fox TA, Rhemtulla JM, Ramankutty N, Lesk C, Coyle T and Kunhamu TK 2017. Agriculture land use change in Kerala, India: Perspective from above and below the Canopy. *Agriculture Ecosystem and Environment* **245**(2017): 1-10.

2.4/T_2-06

Performance of *Gmelina arborea* based Agroforestry Systems in Madhya Pradesh, India

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Keywords: *Gmelina arborea*, agroforestry, biomass, soil properties

1. Introduction

In Central India like Madhya Pradesh, *Gmelina arborea* based agrisilvicultural practices has the potential to provide higher income as well as protect soil health (Swami et al 2003**).** *G. arborea*, which is native to India and a prime fast growing species in farm forests in India, has the potential to replace and act as a substitute for exotic timbers. In the present study, the performances of various pulse crops were studied under *G. arborea* based agroforestry system.

2. Materials and methods

The investigation was carried out in 2021-22 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. Treatments consisted of 6-year old *Gmelina arborea* (8 x3 m spacing) as woody crop and arhar, cowpea and greengram as intercrops in *kharif*. The experiment was carried out in Randomized Block Design. Various growth and yield parameters and soil chemical properties were studied to assess the performance of different crop combinations. The total biomass of the tree (above and below ground) was determined using the following equation (Swamy et al 2004)
$Y = a + bD$, where Y is total biomass (kg), a = -2.421, b = 4.2551, D is DBH (cm)

3. Results and discussion

The perusal of data in Table 1 reveals significant variation in growth and yield parameters. *Gmelina arborea* achieved significantly higher height, dbh and crown spread when grown with greengram over arhar as well as sole crop. These growth parameters of tree species were found at par with cowpea. The height, dbh and crown spread varied from 5.12 to 6.44 m, 7.22 to 9.02 cm and 2.66 to 3.34 m, respectively. Sole tree recorded the lowest values and remained at par with *G. arborea* + arhar. Total biomass production of trees ranged from 141.5 to 179.8 q/ha and biomass production per year ranged from 23.58 to 29.97 q/ha with maximum value under T_3 and minimum under T_4. Grain yield of intercrops varied from 7.02 to 9.04 q/ha. Arhar sole registered the highest value whereas greengram with *G. arborea* recorded the lowest value which was at par with *G. arborea* + cowpea.

Table 1. Performance of 6-years old *Gmelina arborea* and intercrops in different landuse systems in Madhya Pradesh

Name of System	Total height of tree (m)	DBH of tree (cm)	Crown spread of tree (m)	Total Biomass of tree (q/ha)	Grain yield of intercrop in kharif (q/ha)	Biomass production of tree per year (q/ha)
G. arborea + Arhar (T_1)	5.22	7.34	2.78	144.0	8.02	24.01
G. arborea + Cowpea (T_2)	5.94	8.22	3.12	162.78	7.58	27.13
G. arborea + Greengram (T_3)	6.44	9.02	3.34	179.80	7.02	29.97
G. arborea Sole (T_4)	5.12	7.22	2.66	141.50	-	23.58
Arhar Sole (T_5)	-	-	-	-	9.04	-
Cowpea Sole (T_6)	-	-	-	-	8.42	-
Greengram Sole (T_7)	-	-	-	-	7.64	-
$SEm_{(\pm)}$	0.24	0.30	0.11	5.43	0.27	0.84
$CD_{(0.05)}$	0.73	0.93	0.37	16.92	0.81	2.61

The soil chemical properties under different landuse systems varied significantly (Table 2). The values were found maximum under *G. arborea* + greengram (T_3) and minimum under arhar sole. The

O.C., pH, EC, available N, available P and available K ranged as 0.52-0.74%, 5.71-6.46, 0.10-0.18 ds/m, 252-288 kg/ha, 23.4-28.4 kg/ha and 176 -224 kg/ha, respectively.

Table 2. Soil properties under 6-years old *Gmelina arborea* based agroforestry systems

Name of System	O.C. (%)	pH	EC (ds/m)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
G. arborea + Arhar (T_1)	0.62	6.06	0.14	276	31.6	204
G. arborea + Cowpea (T_2)	0.68	6.22	0.15	280	33.4	212
G. arborea + Greengram (T_3)	0.74	6.46	0.18	288	35.8	224
G. arborea Sole (T_4)	0.60	6.02	0.13	268	28.4	196
Arhar Sole (T_5)	0.52	5.71	0.10	252	23.4	176
Cowpea Sole (T_6)	0.56	5.88	0.11	258	25.4	183
Greengram Sole (T_7)	0.58	5.92	0.12	262	27.6	192
$SEm_{(\pm)}$	0.02	0.14	0.01	6.2	0.9	5.66
$CD_{(0.05)}$	0.05	0.42	0.03	18.2	2.5	16.64

The overall performance with respect to growth, yield and soil fertility was found relatively better under *G. arborea* + greengram closely followed by *G. arborea* + cowpea over other treatments.

References

Swamy SL, Kushwaha SK and Puri S 2004. Tree growth, biomass, allometry and nutrient distribution in *Gmelina arborea* stands grown in red lateritic soils of Central India. *Biomass and Bioenergy* **26**: 305-317.

Swamy SL, Puri S and Singh AK 2003. Growth, biomass, carbon storage and nutrient distribution in *Gmelina arborea* Roxb. stands on red lateritic soils in central India. *Bioresource technology* **90**(2): 109-126.

2.5/T_2-09

Role and Constraint of Agroforestry Systems in Achieving Nutritional and Livelihood Security in Chamba Tehsil of District Chamba, Himachal Pradesh

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1. Introduction

Agroforestry plays a crucial role in achieving sustainability in the hill farming system (Carson 1992). Agroforestry is not a new concept in Himachal Pradesh and other Himalayan regions but it has been practiced traditionally since time immemorial (Nautiyal et al 1998). Agroforestry have great role in achieving nutritional security by providing various fruits, pulses, and vegetables as a nutritious diet to farmers and by diversifying sources of income such as by selling timber, fuel wood, and other non-timber forest product for attaining livelihood security.

2. Material and methods

The present study was conducted in Chamba Tehsil of district Chamba of Himachal Pradesh in 2021. The study sites were selected by a multi-stage random sampling technique in which 12 village panchayats and from each panchayat, two villages were selected. In each village, farmers were divided into three different categories based on their land holdings as per the classification of the government of Himachal Pradesh *i.e.*, marginal (<1 ha), small (1-2 ha) and medium (2-5 ha) and 9 farmers were selected from each village and a random sample of three farmers from each category was taken as the ultimate unit of study.

3. Results and discussion

The results revealed five prominent agroforestry systems in the Chamba tehsil of district Chamba. Under Agriculture-based system, Rabi crops such as wheat, potato, pea, onion, cabbage, cauliflower, and Kharif crops like maize, rajmah, ladyfinger, capsicum, and brinjal were grown by the farmers in the area. Some progressive farmers also introduced exotic species of vegetables in their farms to get more financial stability. Agriculture plays a major role in the upliftment of farmers from poverty in the region. Under Fruit-based system, fruits particularly Apple, Mango, Plum, Apricot, and Lemon were grown by the farmers of the region. Under Nut-based system, nut trees, such as the walnut produce high protein foods with low levels of saturated fat that can be a substitute for animal products and helpful for the people of Chamba to fulfill their nutritional needs. Under Fodder-based system, it is found that both, dry and green fodder were sold as well as used to feed cattle in the studied area. Trees found in the region are *Sapindus mukorossi, Celtis australis, Pinus roxburghii, Robinia pseudoacacia, Quercus leucotrichophora, Toona ciliata, Pyrus pashia, Morus alba, Rhododendron arboretum, Melia azedarach, Bauhinia variegate, Cedrus deodara, Albizia lebbeck.* The assessment of agroforestry practices and systems that existed in the study area has helped in identifying general and technical constraints inflicting the tree crop production systems. All categories of farmers faced almost the same constraints/ problem in the study area. Major gaps/constraints faced by the farmers have been identified and their possible solutions have been depicted in Table 1.

Table 1. General/Technological constraints in the existing Agroforestry systems and their solutions

Sr.No	Constraint	Solution
1	Wild/Stray animals like cow, bull, monkey, wild boar etc. were the major threat to the farmers. As they cause heavy damage to their crops.	The problem can be solved by applying proper solar fencing at the boundary of farm. Scheme like Mukhya Mantri Khet Sarankshan Yojna was launched by the state government of Himachal Pradesh. Govt. needs to organize various

		programmes to promote such schemes properly among farmers.
2	Inappropriate irrigation facilities or absence of proper irrigation channels were found in studied sampled area which resulted in the failure of crop or less productive crop.	Popularization of water harvesting techniques like drip irrigation watershed harvesting, rain water harvesting etc., and improved irrigation schemes should be promoted by government.
3	Farmers do not have sufficient knowledge about subsidy schemes.	Efforts should be made for proper knowledge of subsidy schemes as well as technical guidance by authenticated authorities.
4	Agroforestry system identified were traditional and less productive.	Poultry, apiculture, floriculture, medicinal and aromatic plants etc. could be introduced in the existing agroforestry systems to make them productive.
5	Farmers were not getting the fair price of their agricultural produce due to the absence of proper and efficient marketing channels.	Govt authorized sale centers should be opened at accessible places and efficient marketing channels should be developed so that farmers may get fair price for their farm produce.
6	There were not many agroforestry success tales for effective adoption	The experience of success should be shared to the farmers for better adoption of agroforestry.
7	Communication gap in adopting new scientific interventions of agroforestry due to the lack well-developed network for transfer of technology in agroforestry.	Well-developed network should be developed like other state departments such as horticulture, agriculture and forestry so to impart scientific information to the farmers.

References

Carson B 1992. The land, the farmer and the future: a soil fertility management strategy for Nepal. ICIMOD, KTM Nepal Occasional Paper, No. 2.1Office.

Nautiyal S, Maikhuri RK and Saxena KG 1998. Agroforestry systems in rural landscape- a case study in Gharwal Himalaya, India. *Agroforestry Systems* **41:**151-165

2.6/T_2-13

Identification of most Suitable Mango+ *Gmelina arboria* Agroforestry System for Red-Laterite Zone of Eastern India

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Keywords: *Gmelina arboria* agroforestry, mango, Soil parameters, water use efficiency, B:C ratio

1. Introduction

Non-sustainable agricultural production practices have been the major factor that has influenced environmental factors such as the global carbon, water and nutrient cycle around the world. Red and lateritic soils are spread over about 110 Mha in India. Out of which 70 Mha comes under red soil. In general, the productivity of agricultural crops in the Red-Laterite Zone of eastern India is threatened by adverse climatic conditions and depletion of natural resources. Hence, alternative land use systems have to be identified and developed for livelihood security like integration of tree based multilayer cropping system.

2. Materials and Methods

This study was to examine the interaction of perennial trees *i.e.* mango and *Gmelina arboria* with annual field crops on production, changes in soil fertility and economical return. In this experiment, mango was planted at a spacing of 10 × 10 m, whereas, *G. arboria* was planted between two mango trees with 5×5 m spacing as well as boundary of experimental plots at year 2007. It was consisted five arable crops *i.e.* pigeonpea, maize, groundnut and bottle gourd in rainy season and mustard in winter season as intercrops under mango+ *G. arboria* and both tree as sole plantation which was three times replicated under randomized block design.

Table 1. Mango fruit yield, *G. arboria* volume yield and average WUE under different agro-forestry system.

Treatment	Mango fruit yield ($t\ ha^{-1}$)		*G. arboria* volume yield ($m^3\ ha^{-1}$)		Average WUE ($t\ ha^{-1}\ mm^{-1}$)
	1st year	2nd year	1st year	2nd year	
AF_1	6.94^a	9.48^a	31.50^a	42.67^a	74.19^a
AF_2	6.14^c	8.26^b	20.27^d	25.38^d	61.97^b
AF_3	6.68^{ab}	9.11^{ab}	26.27^b	34.83^b	67.30^a
AF_4	6.35^{bc}	8.53^b	23.32^c	29.59^c	65.42^a
AF_5	5.12^d	6.73^c	18.30^d	21.83^e	28.17^c
AF_6	4.70^e	6.06^d	-	-	13.31^d
AF_7	-	-	14.62^e	16.80^f	7.38^d

Mango + *G. arboria* + Pigeon pea (AF_1), Mango + *G. arboria* + Maize followed by Mustard (AF_2), Mango + *G. arboria* + Groundnut followed by Mustard (AF_3), Mango + *G. arboria rboria* + Bottle gourd followed by Mustard (AF_4), Mango+ *G. arboria* (AF_5), Mango (AF_6) and *G. arboria* (AF_7).

3. Results and discussion

The results revealed that the best biometric performances of mango and *G. arboria* were recorded under mango+ *G. arboria*+ pigeonpea. The yields of intercrops were showing the declining trend with age of trees. The system productivity was estimated as a mango equivalent yield to identify the best treatment combination of different agroforestry system and mango+ *G. arboria*+ pigeonpea recorded highest production during both the years. Mango+ *G. arboria*+ legumes crops agroforestry systems were more beneficial for soil properties and water use efficiency as compared sole plantation. The economics of different treatments showed that highest return was recorded under mango+ *G. arboria*+ pigeonpea but B:C ratio was obtained with mango+ *G. arboria*. This study concludes that mango+ *G. arboria*+ legume crops agro-forestry system should be adopted by the local community of Red and Laterite zone of eastern India due to sustainable production, build-up soil quality and more economical.

2.7/T_2-17

Rooting Pattern and Biomass Potential Henna (*Lawsonia inermis* L.) in Legume based Intercropping Systems under Hot Arid Region of India

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Keywords: *Lawsonia inermis*, intercropping, alley, root growth

1. Introduction

The hot arid regions are highly dynamic, sensitive, fragile and are adaptable to human induced changes in climate as well as land use transitions. Due to these adverse conditions, population of arid and semi-arid regions depend on rainfed agriculture (Onyewotu et al 1994: Smith et al 1998). Under such circumstances, understanding how root systems are constructed and their relation to rooting depth and horizontal distribution of root systems of trees/shrubs along with intercrops is important in an agroforestry systems. Henna cultivation is profitable under low rainfall conditions and give assured income returns at low cost investment in drought prone arid and semi-arid regions. And, integration of henna with leguminous crop may ensure the income and productivity of farmers in henna growing areas of India.

2. Materials and methods

The study was conducted in henna intercropping experimental field and the experimental site of henna is located between 25°47′–25°49′N and 73°17′–73°18′E at 217–220 m msl and receives 460 mm annual average rainfall with annual maximum mean temperature of 42°C and minimum 7°C. The henna plants were planted at 60x30 cm in seven different intercropping systems and leguminous crop cluster bean was taken as inter crop during kharif season in second year onwards under rainfed condition. The experiment plot was laid out in a Randomized Block Design with three replications.

3. Results and discussion

The mean of horizontal root length increased from 76.66 cm (H: CB 1:1) to 111.6 cm (Alley cropping; 6 m) while vertical root length varied from 62.33 cm (H: CB 1:2) to 99.66 cm (Sole henna; C). The maximum root spread was recorded in Alley cropping (6m) (98.88 cm) and minimum root spread was in H: CB 1:1 (61.22 cm) followed by Sole henna (C). The maximum above ground biomass was recorded in alley cropping (6 m) while minimum in Alley cropping (3m). Maximum below ground biomass was recorded in H: CB (1:2) followed by strip cropping and sole henna (C) and minimum was in H: CB (1:1). Considering the economical part of the henna and root parameters, sole henna is more suitable among the systems in hot arid and semi-arid region of Rajasthan under rainfed condition. Considering the other best parameters, alley cropping (6 m) is the next best intercropping system among the other systems.

References

Onyewotu LOZ, Ogigirigi MA and Stigter CJ 1994. A study of competitive effects between a *Eucalyptus camaldulensis* shelterbelt and an adjacent millet (*Pennisetum typhoides*) crop. *Agriculture Ecosystem and Environment* **51**: 281–286.

Smith D M, Jarvis P G and Odongo J C W. 1998. Management of windbreaks in the Sahel: The strategic implications of tree water use. *Agroforestry systems* **40:** 83-96.

2.8/T_2-20

Growth Performance of Bharangi (*Clerodendrum serratum* Linn.) under Different Agroforestry Systems

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1. Introduction

Bharangi (*Clerodendrum serratum*, Linn) is a deciduous shrub, belonging to the family Lamiaceae, is an important medicinal plant and wild leafy vegetable widely distributed throughout India, but mostly found in the forest of Western Ghats and Eastern India; Sri-Lanka and Malaysia. Appropriate intercropping with combinations of arable crops and trees in agroforestry systems is of immense importance for increase farm yields (Manjunatha 2004).

2. Materials and methods

The field experiment was carried out in the Central Research Station, Tetawali Block; Experimental farm of College of Forestry, Dapoli, during 2021-22 in Randomized Block design (RBD) with seven treatments comprising of six agroforestry plantations *viz*., bharangi with of bamboo (T_1), nimbara (T_2), cashew (T_3), teak (T_4), sandal (T_5), ain (T_6) and one sole bharangi (T_7) at 1 x 1 m in three replications. Growth observations were statistically analysed using RBD (Fischer and Yates 1963).

3. Results and discussion

The maximum survival percentage (94.17%), number of shoots (3.07), shoot length (59.40 cm), number of leaves (40.47), length of leaves (22.43 cm), root length (41.70 cm), fresh shoot weight (182 g), dry shoot weight (104 g), fresh root weight (42.27 g), dry root weight (23.90 g), fresh leaf weight (64.14 g), dry leaf weight (34.33 g) was recorded in teak based agroforestry system (Table 1a & 1b). However, all the growth parameters was recorded minimum in bamboo based agroforestry system. The trend in all the growth parameters at the end of ten months as influenced by different agroforestry systems was found as $T_4 > T_6 > T_2 > T_3 > T_7 > T_5 > T_1$. Hence, Bharangi proved as better intercrop under teak based agroforestry system.

Table 1a. Growth performance of Bharangi different under agroforestry systems at 10 months after planting

Treatment	Survival %	Shoot length (cm)	No. of leaves	No. of shoots per plant	Root length (cm)
T_1	39.25	25.1	26.73	2	25.26
T_2	85.5	42.07	34.53	2.67	39.42
T_3	73.25	39.47	27.13	2.73	39.42
T_4	94.17	59.4	40.47	3.07	41.7
T_5	66.58	40.23	27	2.67	35.1
T_6	86.08	59.13	37.07	2.87	40.67
T_7	66.33	40.37	30.07	2.53	36.4
Mean	73.02	43.68	31.86	2.65	36.85
S.Em.±	2.19	1.36	0.99	0.08	0.31
LSD (0.05)	6.75	4.18	3.04	0.24	0.9

Table 1b. Growth performance of Bharangi different under agroforestry systems at 10 months after planting

Treatment	Fresh root weight (g /plant)	Dry root weight (g/plant)	Fresh shoot weight (g /plant)	Dry shoot weight (g/plant)	Fresh leaf weight (g /plant)	Dry leaf weight (g/plant)
T_1	21.61	9.1	121.33	55.78	26.51	6.59
T_2	37.92	19.99	157.89	83.08	57.93	28.08
T_3	35.38	18.55	152.78	78.97	53.85	24.07
T_4	42.27	23.9	182	104	64.14	34.33
T_5	34.56	17.56	148.55	73.82	43.76	13.66
T_6	41.11	22.37	173.89	97.04	62.04	32.18
T_7	31.72	15.82	153	78.11	48.14	18.22
Mean	34.94	18.18	155.63	81.54	50.91	22.45
S.Em.±	0.36	0.2	0.18	0.34	0.19	0.25
LSD (0.05)	1.1	0.61	0.54	1.05	0.58	0.78

References

Fischer RA and Yate I 1963. Statistical methods. Oliver and Bayel, Edinburg.

Manjunatha BK, Krishna V and Pullaiah T 2004. Flora of Davanagere District, Karnataka, India. Regency Publications, New Delhi, India. 311.

2.9/T_2-33

Effect of Fertilizer Doses on Flower and Oil Yield of *Michelia champaca* in Konkan Region of Maharashtra

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1. Introduction

Michelia champaca L. belongs to the family Magnoliaceae. Southeast Asia's tropical and subtropical regions are its native habitats. It has commercial value, especially the flowers, since the essential oil from the blossoms is used to make fragrances, cosmetics, and hair oils. It also has a variety of pharmacological properties, including antimicrobial, antioxidant, anti-diabetic, and anti-ulcer properties.

2. Material and methods

The study was carried out in 4 years old *M. champaca* plantation planted in a split-plot design in the field of Pitambari Farm House, Sakhloli. The soil analysis of the plot before the application of fertilizer was done for major nutrients like N, P, K, EC, and pH. The tree girth was measured at the collar region with using vernier caliper. Flower oil was extracted using the Soxhlet apparatus.

3. Results and discussion

The result evinced that different inorganic fertilizer doses significantly affected the number of flowers per plot (Table 1). Maximum flowers (4321.14 per plot) were recorded in treatment N_1 and minimum (4169.43 per plot) was in treatment N_2. In control, maximum flower (4261.12 per plot) was in treatment N_5 and minimum (4171.37 per plot) in treatment N_6. There was no effect on flower oil yield as affected due to pruning level and fertilizer application. The oil yield extraction at different intervals showed oil percentage of 0.0114.

Table 1. Effect of Pruning and fertilizer doses on number of flowers per plot of *M. champaca*

Number of Flower per plot		Number of flower ha^{-1}
Treatment	Pruning	Pruning
P1 (4 Feet)	4314.34	153522.2
P2 (6 Feet)	4195.48	135666.7
SE (m)±	32.36	
CD at 5 %	NS	
Control (4 Feet)	4259.26	140333.3
Control (6 Feet)	4133.71	136244.4
Fertilizer (Split doses)		
N1 30:00:00 NPK	4321.14	140422.2
N2 30:37.5:22.5 NPK	4169.43	138233.3
N3 45:00:00 NPK	4297.68	146155.6
N4 45:56.25:33.75 NPK	4235.87	151511.1
N5 60:00:00 NPK	4309.57	144466.7
N6 60:75:45 NPK	4195.77	146533.3
SE (m)±	80.59	
CD at 5 %	NS	

Fertilizer (Recommended doses)		
N_1 240:00:00 NPK	4199.62	139522.2
N_2 240:300:180 NPK	4256.12	141411.1
N_3 360:00:00 NPK	4048.96	127988.9
N_4 360:450:270 NPK	4246.70	143944.4
N_5 480:00:00 NPK	4261.12	141355.6
N_6 480:600:360 NPK	4171.37	135700.0
Interaction effect		
SE (m)±	131.60	
CD at 5 %	NS	
Mean	454.91	
Absolute control	3975.096	53333.33

P= Per Plot; P1= Plot 1, P2= Plot 2, NPK=Nitrogen+ Phosphorus+ Potassium, N= (No) Treatments.

2.10/T2-35

Evaluation of Boundary-Grown Fodder Bank Trees in Smallholder's Farm in Central Kerala, India

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Keywords: Fodder bank, small holders, crude protein, dry matter

1. Introduction

Animal husbandry in Kerala is constrained due to protein deficit, making farmers rely on costly concentrates which severely reduces their profit. Cultivation of fodder bank trees on boundaries of smallholder's farm can be better alternative to concentrates in land-scarce Kerala. Thus, 2-year study was carried out to evaluate fodder trees when planted on boundaries of smallholder's farms in Thrissur, Kerala.

2. Material and methods

Five species (*Morus indica*, *Neolamarckia cadamba*, *Calliandra calothyrsus*, *Sesbania grandiflora*, and *Gliricidia sepium*) planted with a spacing of 45 × 45 cm on four (replication) sides of the farm in RBD in 2019. Each tree was maintained at 1m height and harvested after every two months in rainy season and three months in summer season into leaf and edible stem fraction. Fresh fodder yield, fodder dry matter yield and protein yield was recorded and analysed by ANOVA using SPSS at 1% significance level.

3. Results and discussion

After 2-year of planting, the order fresh leaf fodder, fresh stem fodder and total fresh fodder yield was *N. cadamba* followed by *C. calothyrsus*, *M. indica*, *G. sepium*, and *S. grandiflora*. However, in terms of total dry matter yield *C. calothyrsus* and *N. cadamba* performed better followed by *M. indica*, *G. sepium*, and *S. grandiflora*. Highest crude protein (CP) yield was obtained in *C. calothyrsus* followed by *N. cadamba*, *M. indica* and *G. sepium*, and *S. grandiflora*, respectively. Although highest CP% in was recorded in *C. calothyrsus*, total CP% did not significantly differed among treatment. The lowest fodder yield in *S. grandiflora* pertains to its lower survival after subsequent cuttings. Planting *N. cadamba*, *C. calothyrsus* and *M. indica* on the boundaries of the farm can provide much-needed protein and high-quality feed, enabling sustainable and affordable animal production.

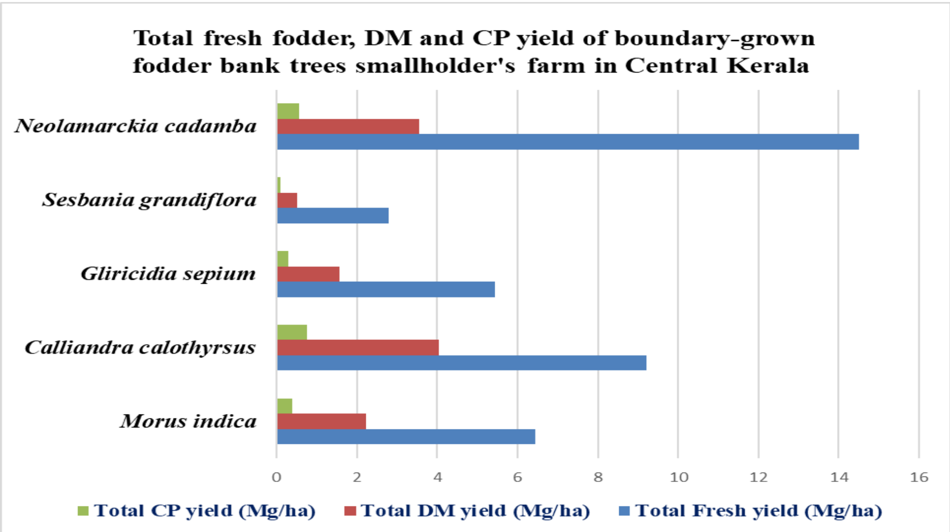

Fig.1. Total fresh fodder yield, total fodder DM (dry matter) yield, and total CP (crude protein) yield of boundary-grown fodder bank trees in smallholder's farm in Pananchery panchayat, Thrissur, Kerala after two years of planting.

2.11/T_2-37

Present Status and Mitigation Strategies of Human Animal Conflict in India

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Keywords: Human-animal conflict, mitigation strategies, traps

1. Introduction

Human-animal conflict refers to the negative interactions between human and animal with undesirable impact on people and natural resources. Its mitigation is an important priority for the management of biodiversity and protected areas. Due to an expanding human population, it is almost inevitable to stop conflict. So, it's time to rethink and work together to reduce, manage conflicts and foster coexistence.

2. Material and methods

Previously, conflict mitigation strategies utilized translocation, population size regulation and endangered species preservation also some traditional and repellent approaches like auditory repellents, predator deterring guard dogs, noise crop guarding, fire, trapes, air borne missiles, decay foods *etc*. Recent management now uses an interdisciplinary set of approaches to solve conflicts. These include applying scientific method like use of advanced very high-resolution radiometer (AVHRR), Landsat Thematic Mapper (LTM), Multispectral scanner (MSS), Spot data, aerial photography and by the improved technique of coexistence.

3. Result and discussion

- India is one of the few countries in the world that have explicitly addressed coexistence for human animal conflict in their national law.
- The main goal of management is to enhance safety of people and wildlife and to create mutual benefits of coexistence.
- Project REHAB launched by the Khadi and Village Industries Commission (KVIC) Mitigates human-elephant conflicts without causing any harm to elephants also give empowerment to local people by bee keeping.
- WWF and Government of Assam had developed the Sonitpur Model during 2003-2004, in which community members were connected with the state forest department to mitigate elephant attack and crop destruction and the crop losses dropped to zero for four years running. Human and elephant deaths also reduced significantly.

References

Kumar K and Bisht SS 2020. Study on human wildlife conflict in Chenab valley of Jammu and Kashmir India. *Indian Journal of Ecology* **47**(3): 875-877.

Thakur RK, Walia A, Mehta K, Kumar V and Lal H 2022. Increasing interference of stray and wild animals in farming: Reflections from Western Himalayan Foothills. *Indian Journal of Ecology* **49**(1): 57-63.

2.12/T$_2$-44

Agroforestry based Farming System in Nagaland- A Case Study

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Keywords: Farming system, Zabo farming, agroforestry, coffee

1. Introduction

Nagaland is known for its biological richness and unique farming systems due to its diversified landforms, relief, environmental and socioeconomic conditions. Accurate assessment and understanding of structural and functional attributes of farming system is important not only to determine types of species grown in the area but for their sustainable management and utilization. It also helps to identify the threats to biodiversity from advancing anthropogenic and climatic change, allowing strategies to be developed and implemented in right perspective.

2. Materials and methods

Papers published in different scientific journals were reviewed to compile the data related to the different traditional systems present in Nagaland. The data compilation included thesis reports, proceedings, newspaper reports and publications. In addition, the field survey was also done to study the structural attributes of few agroforestry systems and also to verify the information reported in the published papers.

3. Results and discussion

Nagaland has a wide range of climatic, edaphic, topographical, biological and cultural diversity. Thus, many traditional trees based integrated farming systems exists in this state. These traditional farming systems have been developed over the years based on the knowledge of the ethnic communities to meet their livelihood requirements and are an integral part of the socioeconomic and cultural identity of the local communities. Some of the renowned sustainable agroforestry systems are Zabo farming, Alder based farming system, traditional homestead farming, coffee-based farming system, cardamom-based farming system. Most of these traditional farming systems are diversified, location specific and highly sustainable comprising of traditional water harvesting systems, soil fertility management and erosion control. However, these systems need to be further improved with suitable scientific interventions exploring and recognizing the traditional knowledge of the locals. The highly sustainable and remunerative traditional tree-based farming systems needs to be disseminated into new areas of similar agro-ecological conditions to meet the increasing household demands and improving the socio-economic conditions of local communities.

2.13/T_2-52

Standardization of Vegetative Propagation in *Terminalia chebula* Retz.

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Keywords: *Terminalia chebula,* vegetative propagation, root stock, grafting, budding

1. Introduction

Terminalia chebula Retz., a deciduous tree of immense importance, also referred to as multipurpose tree species. Tibetans refer it as 'King of Medicine' whereas commonly it goes by various names like chebulic myrobalan or black myrobalan (English), Harad (Hindi), Haritaki (Ayurveda), Halela zard (Unani) *etc*. It is indigenous to India and Southeast Asia. In India, it is widely distributed in mixed dry deciduous forests and can be found frequently in tropical and subtropical zones, mostly in hilly tracts. It has very low natural regeneration, seeds have poor germination capacity, juvenile period is long for fruits production and there is lack of availability of superior germplasm. Thus, the availability of superior germplasm and shortening of long juvenile period can be resolved by the adoption of various vegetative propagation techniques. Hence the present investigation entitled was undertaken.

2. Material and methods

The present investigation was carried out in the Experimental Farm of Division of Agroforestry, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, India during the year 2022. The experiment was laid out in complete randomized design (CRD factorial) with three replications. Scions of *T. chebula* were grafted on three different rootstocks *viz*. *T. chebula* (R_1), *T. bellirica* (R_2) and *T. arjuna* (R_3). The grafting and budding methods used were cleft grafting (V_1), side-veneer grafting (V_2) and patch budding (V_3). In total there were 9 treatment combinations. Various parameters studied were number of days taken to bud sprouting, graft take ratio, graft survival ratio, graft shoot diameter (mm) (60 DAG & 90 DAG), number of shoots per plant (60 DAG & 90 DAG), number of leaves per plant (60 DAG & 90 DAG), shoot length above graft union (cm) (60 DAG & 90 DAG), total shoot length (cm) (60 DAG & 90 DAG), shoot biomass (g), length of primary root (cm), number of secondary roots, root biomass (g), root: shoot ratio.

3. Results and discussion

The results showed that out of all the grafting techniques cleft grafting (V_1) was most promising as it showed significant results on principal parameters like graft survival ratio and graft take ratio, patch budding was also successful in certain parameters like number of days taken to bud sprouting, graft shoot diameter (mm), shoot length above graft union (cm) and total shoot length (cm). In case of rootstocks *T. arjuna* (R_3) performed well on most of the growth parameters. Overall, treatment combination R_3V_1 (*T. arjuna* x cleft grafting) showed best results among all. It could be due to the better cambium fusion in cleft grafting (Rahayu et al 2020) and comparatively better root morphology of *T. arjuna* which might ameliorate the uptake of nutrient and moisture (Zhu et al 2021). Therefore, it can be concluded from the present study that the *T. arjuna* as a rootstock can successfully be cleft grafted with superior *T. chebula* scion to obtain better results.

Table 1 Summary of treatments performance with regard to the highest value

Observations	Treatments
Number of Days Taken to Bud Sprouting	$T_9 = T_7 = T_3$
Graft Take Ratio (%)	T_7
Graft Survival Ratio (%)	T_7
Graft Shoot Diameter (mm)	T_9
Number of Shoots Per Plant	T_7
Number of Leaves Per Plant	T_7
Shoot Length Above Graft Union (cm)	T_9
Total Shoot Length (cm)	$T_9 = T_3$

Shoot Biomass (g)	T_7
Length of Primary Root (cm)	T_1
Number of Secondary Roots	T_7
Root Biomass (g)	T_3
Root: Shoot Ratio	T_1

T_1 = *Terminalia chebula* Retz. x Cleft Grafting, T_3 = *Terminalia chebula* Retz. x Patch Budding, T_7 = *Terminalia arjuna* Bedd. x Cleft Grafting, T_9 = *Terminalia arjuna* Bedd. x Patch Budding and (=) = At par.

References

Rahayu E S, Retnoningsih A, Abdullah M, and Sholihah N K, 2020. Effect of rootstock variety, cut surface and grafting time on graft success of *Mangifera indica* L. var. wirasangka. *Journal of Physics: Conference Series*1918:e052042.

Zhu H, Zhao J, and Gong L. 2021. The morphological and chemical properties of fine roots respond to nitrogen addition in a temperate Schrenk's spruce (*Picea schrenkiana*) forest. *Nature Portfolio* 11: e83151.

2.14/T_2-53

Floristic Composition and Distribution of Plant Communities under Different Traditional Agroforestry Systems in Takoli Gad Watershed of Garhwal Himalaya

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Keywords: Agroforestry, floristics, density, Important Value Index, shrubs, herbs

1. Introduction

Agroforestry has been practiced traditionally by farmers in the Himalayas since time immemorial. In the hill farming system, it is crucial to ensuring sustainability. The traditional land management system is an important component of the local environment and civilization as it maintained agricultural output and met the requirements of the local population in Garhwal Himalaya (Maikhuri *et al*., 2000).

2. Material and methods

The study was carried out in Lower (300–1200 masl) and Middle (1200-2000 masl) altitudinal ranges of the Takoli Gad Watershed. Thorough reconnaissance survey was carried out for identifying traditional agroforestry systems and randomly 10×10m, 5×5m and 1×1m quadrats were laid out for trees, shrubs, crops and herbaceous plants respectively in each system. The Important Value Index(IVI) which is an integrated measure of the relative frequency, relative density and relative dominance/abundance was calculated for each species as per standard procedure.

3. Results and discussion

Three traditional agroforestry systems were identified viz. Agri-silviculture, Silvi-pastoral and Homegarden in Lower and Middle altitudes. Based on density values, in agri-silviculture sytem, maximum density of trees (522 trees/hectare) and herbs (82222 plants/hectare) was found in Middle altitude. Similarly, in agricultural crops, maximum density was found in middle altitude (138889 plants/ha) followed by lower altitude (124545 plants/ha). Although in homegarden, maximum density of trees (600 trees/hectare), agricultural crops (94444 plants/ha), were found in Middle altitude while maximum density of herbs was reported in lower altitude (55455 plants/hectare). In silvi-pastoral system, maximum density of tree (622 trees/hectare), shrubs (2444 plants/hectare), grasses (105556 grass/hectare) were found in Middle altitude whereas maximum density of herbs was reported in lower altitude (100000 plants/ha) followed by middle altitude (44444 plants/ha).

Reference

Maikhuri RK, Semwal RL, Rao KS and Singh K 2000. Growth and ecological impacts of traditional agroforestry tree species in Central Himalaya, India. *Agroforestry Systems* **48**, 257–271.

2.15/T_2-54

Structure, composition, and distribution pattern of agroforestry flora along altitudinal gradient in Kirtinagar Block of district Tehri Garhwal, Uttarakhand, India

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Keywords: Agroforestry**,** density, frequency, IVI, homegarden

1. Introduction

In India, agroforestry has long been recognised as a traditional method of land usage. As per FSI report 2019, 11.54 m ha or 3.39 % of the nation's geographic area of agroforestry are being reported. A significant portion of Garhwal Himalaya constitutes major part of Central Himalaya that have diversified traditional agroforestry systems (Kala 2010).

2. Material and methods

The study was conducted in Kirtinagar Block of district Tehri Garhwal (Uttarakhand). Three different indigenous agroforestry systems i.e., Agrisilviculture, Silvipasture and Homegarden were selected from 300-1200 m amsl (Lower Altitude) and 1200-2000 m amsl (Upper Altitude) for documentation the agrobiodiversity. Quadrat method was adopted to access the agrobiodiversity, in which quadrats 10×10m, 5×5m, 1×1m were respectively laid out for trees, shrubs, crops and herbs. Further, density, frequency, IVI, and abundance-frequency ratio was calculated for each component of agroforestry system.

3. Results and discussion

In upper altitudes dominating tree species was found *Celtis australis in* agrisilviculure (94.32) and silvipasture (82.15) and *Citrus sinensis* in Homegarden (48.20), while in lower altitudes *Grewia optiva* (110.39)*, Mallotus phillipensis* (34.07)*, Morus alba* (39.56) *respectively in* agrisilviculure, silvipasture and Homegarden. Among the crops *Eleusine coracana* was prominent one in upper (111.30) and lower (82.13) in agrisilviculture system, *Capsicum annum* in upper (75.68) and lower (99.93) in Homegardens. In silvipasture system, *Eupatorium adenophorum* (68.24) *and Rhus parviflora* (40.71) were dominated shrubs, *Apluda mutica* (79.31) and *Crysopogon montanus* (74.92) were prominent grasses in upper and lower altitudes respectively. The values under bracket indicating IVI. The dominating herb was *Bidens pilosa* in all systems of upper altitude, silvipasture of lower altitude and *Ageratum conyzoides* in agrisilviculture and homegarden of lower altitude.

Reference

Kala CP 2010. Status of an indigenous agro-forestry system in changing climate: A case study of the middle Himalayan region of Tehri Garhwal, India. *Journal of Forest Science* **56**(8): 373–380.

2.16/T_2-57

Performance of Mustard Crop under Citrus Based Agroforestry Systems in Vidarbha Region of Maharashtra

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Keywords*:* Citrus, agroforestry, *Tectona grandis*, *Eucalyptus*, *Ailanthus excelsa,* mustard

1. Introduction

Agroforestry is one of the best options to increase the tree cover outside the forest. An efficient agroforestry system not only maximizes the benefit it provides but also ensures the link to climate change mitigation. Trees are important carbon warehouses that filters massive quantities of carbon from the atmosphere, trapping it in their biomass. An average tree can remove about 23 kg of carbon dioxide from the atmosphere annually. In agroforestry systems, the amount of carbon sequestration is further increased. The interaction of the different components of agroforestry systems can help absorb and sequester carbon dioxide and other greenhouse gasses from the atmosphere. Thus, trees in an agroforestry system make it a potential strategy in mitigating climate change.

2. Material and methods

The selected level field of 0.29 ha in which horti-silviculture-system including Mandarin, *Tectona grandis, Eucalyptus tereticornis* and *Ailanthus excelsa* planted during 2015 was selected. The experiment was laid out in Randomized Block Design (RBD) with four replications. There were 20 treatments. The size of unit plot was 6 X 6 m^2. The Mandarin was planted at a distance of 6 x 6 m^2, whereas the forest species were planted at a distance of 3 m between two Mandarin plantations. Mustard (*Brassica juncea*) variety Pusa bold was cultivated as per recommended package and practices in rabi season. The treatments include T_2 - Sole Mandarin + Mustard, T_3 - Mandarin + *Tectona grandis* + Mustard, T_4 - Mandarin + *Eucalyptus tereticornis* + Mustard and T_5 - Mandarin +*Ailanthus excelsa*+ Mustard. were frame, while T_1 – sole mustard field area without trees were laid down to accesses the growth and yield performances of mustard crop affected by microclimate condition at different growth stages.

Table 1. Effect of tree crops on grain yield (q ha^{-1}), straw yield (q ha^{1}), harvest index (%), test weight (gm) 1000 $seed^{-1}$, fresh weight (kg m^{-2}), dry weight (kg m^{-2}), fresh root weight $plant^{-1}$ (gm) and root length (cm) mustard under citrus based different agroforestry systems

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest Index (%)	Test weight (gm) 1000 $seed^{-1}$	Fresh weight (kg m^{-2})	Dry weight (kg m^{-2})	Fresh root weight $plant^{-1}$ (gm)	Root length (cm)
Sole cropping	10.31	20.48	33.48	4.50	1.57	0.67	8.80	14.50
Sole Mandarin	8.51	18.05	32.04	4.23	1.46	0.60	8.53	14.25
Mandarin + *Tectona grandis*	7.45	16.24	31.44	3.90	1.11	0.44	8.10	12.95
Mandarin + *Eucalyptus tereticornis*	7.93	17.04	31.75	4.15	1.37	0.57	8.33	13.15
Mandarin + *Ailanthus excels*	6.82	15.00	31.25	3.70	0.79	0.35	7.94	11.65
SE(d) ±	0.87	1.45	1.06	0.47	0.19	0.13	2.92	3.44
CD @ 5%	NS	NS	NS	1.45	0.59	NS	NS	NS

3. Result and Discussion

The growth performance and yield of Mustard under different set of treatments *viz*., T_1 (Sole Mustard), T_2 (Sole Mandarine + Mustard), T_3 (Mandarin + *Tectona grandis* + Mustard), T_4 (Mandarin + *Eucalyptus tereticornis* + Mustard) and T_5 (Mandarin + *Ailanthus excelsa* + Mustard) was recorded. The growth parameter and yield of mustard crop was found maximum in open field crop (Sole Mustard) than the treatment under citrus based agroforestry systems and it was 25.57, 56.35, 44.00 and 63.12 per cent higher as compared to treatment T_2, T_3, T_4 and T_5, respectively. The grain and straw yield of mustard was 5.75 and 11.90 q ha^{-1} in crop of open field (Sole Mustard). As regard the soil fertility, the most important parameter *i.e.,* the organic carbon was significantly increased in sole cropping (0.57), sole Mandarin (0.53) and Mandarin + *Ailanthus excelsa* (0.48). Whereas, it was decreased under Mandarin + *Tectona grandis* (0.48) and Mandarin + *Eucalyptus tereticornis* (0.44) after the harvesting of rabi mustard crop.

2.17/T_2-58

Performance of Different Grasses in *Terminalia chebula* based Agroforestry System in Sub-tropical Region of Jammu, India

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Keywords: Agroforestry, *Terminalia chebula*, grasse, harad, *Pennisetum purpureum*

1. Introduction

Livestock production is the backbone of Indian agriculture. Even after having a very high population of livestock, the productivity of Indian animals is relatively low. The major reason for low productivity is deficiency of quality feed and fodder. Therefore, there is an urgent need to increase the production and at the same time improve the productivity of fodder crops in order to meet the fodder needs in the farming systems.

2. Materials and methods

The study was carried out at experimental farm of Division of Silviculture and Agroforestry, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, India. Seven types of grasses were maintained as intercrop under the harad (*Terminalia chebula*) based agroforestry system. The experiment was laid out in Randomized Block Design (RBD) with seven treatments and three replications. The growth parameters like plant height, diameter at breast height and crown spread of trees and dry biomass of grasses were recorded and analyzed.

3. Results and discussion

The results presented in Table 1 revealed that plant height, DBH and crown spread of harad trees were statistically non-significant. Similar study undertaken by Korwar et al (2006) also found that castor and green gram grown under agroforestry tree species had no significant influence. The result of the present study revealed that different treatments have significant effect on grass yield. Treatment combination Harad **+** *Pennisetum purpureum* recorded highest yield of 6.64 t/ha which was statistically at par with T_1 (Harad **+** *Setaria anceps* var. S-25) and T_3 (Harad **+** *Setaria anceps* var. PSS-1) whereas, lowest yield of 2.47 t/ha was found in T_7 (Harad + Natural grass).

Table 1. Growth performance of harad and dry yield of different grass species

Treatments	Tree growth			Grass yield on dry basis (t/ha)
	Plant Height (m)	DBH (cm)	Crown spread (m)	
T_1 (Harad + *Setaria anceps* var. S-25)	0.66	3.29	0.63	6.43
T_2 (Harad + *Sorghum bicolor*)	0.59	3.40	0.62	3.34
T_3 (Harad + *Setaria anceps* var. PSS-1)	0.53	3.17	0.62	6.02
T_4 (Harad + *Pennisetum purpureum*)	0.52	3.22	0.64	6.64
T_5 (Harad + *Paspalum* spp.)	0.58	3.21	0.67	2.62
T_6 (Harad + *Bracharia decumbens*)	0.46	3.39	0.63	2.88
T_7 (Harad + Natural grass)	0.51	3.26	0.60	2.47
SE ±	0.06	1.41	0.02	0.46
$CD_{0.05}$	NS	NS	NS	1.43

Reference

Korwar GR, Pratibha G, Ravi V and Kumar DP. 2006. Performance of castor (*Racinus communis*) and green gram (*Vigna radiata*) in agroforestry systems in semi arid tropics. *Indian Journal of Agronomy* **51**: 112-115.

2.18/T_2-59

Agroforestry: A Livelihood Possibility in the Resource Poor Area-A Case Study from Makawanpur District, Nepal

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Keywords: Agroforestry, trees, subsistence farming, Nepal

1. Introduction

Agroforestry practices are increasingly gaining momentum all over the world including South Asia region and Nepal as it accelerates the livelihood of majority of population in this part of the word. A case study was carried out in Makawanpur district of Nepal to find the role of traditional agroforestry practice in income generation and securing the livelihood

2. Material and methods

A case study was carried out in Makawanpur district to assess the role of Agroforestry practice. Division Forest Office, and Agricultural Office at Makawanpur district and field level staffs of those offices were was contacted for getting information about the agroforestry practicing farmers in the district. Prominent farmers in ward no 07, Gadhi Rural Municipality were finally chosen for undertaking case study. Repeated visit to the site, Intensive interview, field visit, Focus Group Discussion were conducted for collecting needed data.

3. Results and discussion

Located in the remotest parts of Makawanpur district, it is and is about 30 kilometers from the main city center. The area was not accessible until five years ago. But, now it has been connected with the rough road from the city center and can be reached to the site with small vehicles. Most of the people are subsistence farmers and laborers. Some are involved in business and some other are also workers in foreign land. Most of the people have insignificant piece of land which cannot feed them round the year. One farmer took an initiative to start agroforestry practice in his own way and now is receiving satisfactory benefit from his endevours while supporting other poor households in the village.

Table 1. Important woody plants grown in agroforestry system

Sr. No.	Nepali Names	Botanical Names	Sr. No.	Nepali Names	Botanical Names
1	Champ	*Michelia champaca*	13	Jamun	*syzygium jambo*
2	Bakaino	*Melia azadarach*	14	Fanir	*Syzygium cumini*
3	Malasian Sal	*Shorea Borneensis*	15	Nigalo	*Drepanostachyum falcatum*
4	Paulonia	*Paulownia*	16	Bans	*Dendrocalamus spp*
5	Khayar	*Acacia catechu*	17	Tama Bans	*Dendrocalamus hamiltonii*
6	Pine	*Pinus wallichina*	18	Khanayo	*Ficus semicordata*
7	Eucalyptus	*Eucalyptus*	19	Kutmire	*Litsea monopetala*
8	Uttis	*Alnus nepaulensis*	20	Saj / Asna	*Terminalia tomentosa*
9	Siris	*Albizzia procera*	21	Badahar	*Artocarpus lacucha*
10	Paiyu	*Prunus cerasoides*	22	Gayo	*Bridelia retusa*
11	Saur	*Betula alnoides*	23	Rai Khanyu	*Ficus cunia*
12	Kadam	*Neolamarckia cadamba*			

Reference

Ulak S, Lama B, Pradhan DK, and Bhattarai S 2021. Exploring agroforestry systems and practices in the Terai and hill regions of Nepal. *Banko Janakari* **31**(2): 3–12.

2.19/T_2-62

Economical analysis of Teak - Rice based Agrisilviculture System in Chhattisgarh

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Keywords: Teak, rice, agri-silviculture system, economics

1. Introduction

Tree shade is considered as one of the causes of reduced crop returns in grouped plantations including those who appreciate the shade and are vulnerable to shade. If the tree is not pruned, this condition is more serious. Shade has a major impact on the productivity of rice crops. The height, panicle/hill, and panicle/grain and grain production is reduced. Shade promotes cell development and speedy cell division and increases the length and height of the plant blade (Schoch, 1972).

2. Materials and methods

Paddy fields along with *Tectona grandis* planted bunds were selected in village Bade Urla in Raipur district, Chhattisgarh. Economics of standing trees was estimated through volume (using Huber's formula) and returns were estimated.

3. Result and discussion

It was observed that the cost of cultivation of Teak based agroforestry systems was more as compared to the cost of cultivation of control. The gross return from Teak based agroforestry systems was more as compared to the gross return obtained from the control (Table 1). In Teak based agroforestry system, highest returns were obtained from teak + paddy system (Rs. 2, 85,231/ha) while the return from the controlled condition of same area were Rs. 97,775/ha. The B: C Ratio of the teak based agroforestry system was higher as compared to its control (Table 1).

Table 1. Economic attributes of rice as influenced by control farming and *teak* based AF system

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross Return (Rs. ha^{-1})	B:C Ratio
Control	32249	97775	3.03
Under agroforestry system	66484	285231	4.29

Reference

Schoch PG 1972. Effects of shading on structural characteristics of the leaf and yield of fruit in *Capsicum annum*. *J. Amer. Soc. Hort. Sci.* **97**(4): 461-464.

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Assessment of Leaf Fodder Quality of *Melia dubia* Genetic Resources for Proximate and Mineral Composition

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1. Introduction

Livestock rearing is one of the major occupations in India. Significance of the livestock sector can be appreciated from the fact that it contributes about 8.5- 9.00% to the country's GDP. With world's largest livestock population, India faces problem in meeting its fodder requirement. Fodder trees are highly nutritious, easy to grow, improve soil fertility and are relatively easy to manage. The current investigation was to determine the fodder quality of thirty *Melia dubia* genetic resources.

2. Materials and methods

Leaves were obtained from the felled thirty genetic resource of *M. dubia* from the 6-year-old existing plantation located at Forest College and Research Institute, Mettupalayam. These leaves were dried and powdered. The leaves samples were subjected to analysis for proximate and mineral composition such as dry matter, ash, crude fat (CF), crude protein (CP), nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg) and carbohydrate content. All these analyses were carried out as per the standard guidelines of AOAC (1990). The data generated were subject to the statistical analysis using completely randomized design.

3. Results and discussion

The results revealed that thirty *M. dubia* genetic resources differs significantly for different parameters (Table 1). All the genetic resources showed higher dry matter as well as lower ash content, which implies their suitability as a good fodder, among them highest dry matter (37.95%) and lowest moisture content (62.01%) was registered by MTPMD 1. The main features of fodder are high crude protein and mineral content. The highest CP was registered by MTPMD 1 (17.30 %) and the lowest CP was registered by MTPMD 2 (16.80 %). MTPMD 1 registered highest N content (2.77 %) and MTPMD 2 and MTPMD 11 registered lowest N content (2.69 %). Maximum phosphorus content was found in MTPMD 1 and MTPMD 30 (0.34 %), minimum was in MTPMD 11 (0.28 %). Highest potassium content was registered by MTPMD 1 and MTPMD 30 (0.09 %) lowest was in MTPMD 11 and MTPMD 25 (0.06 %). Highest magnesium content was found in MTPMD 1, MTPMD 13, MTPMD 22, MTPMD 30, MTPMD 42 (0.33 %) and minimum was in MTPMD 12 & MTPMD 26 (0.29 %). Among thirty *Melia dubia* genetic resource MTPMD 1 exhibited the better values for proximate analysis as well as mineral composition thus it proved to be superior genetic material with improved leaf fodder quality and extended scope for further breeding programme.

Reference

Association of Official Analytical Chemists (AOAC) 1990. *Official methods of analysis of the Association of Official Analytical Chemists (15th edn)*, Washington DC, USA.

Table 1. Proximate and Mineral analysis of *Melia dubia* genetic resources for leaf fodder

Sl. No.	Genetic resource no.	MC (%)	DM (%)	Ash (%)	CF (%)	CP (%)	CHO (%)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
1	MTPMD 1	62.01	37.95*	7.35	3.21*	17.30*	17.10*	2.77*	0.34*	0.09*	2.29*	0.33
2	MTPMD 2	65.31*	34.65	7.25	2.96	16.80	16.30	2.69	0.29	0.07	2.21	0.31
3	MTPMD 3	62.65	37.31	7.40	3.01	16.95	16.00	2.71	0.32	0.08	2.20	0.32
4	MTPMD 4	62.41	37.55*	7.45*	2.76	17.10	16.50*	2.74	0.30	0.08	2.24	0.30
5	MTPMD 5	63.11	36.85*	7.21	3.11	17.00	15.50	2.72	0.31	0.07	2.23	0.30
6	MTPMD 6	66.11*	33.85	7.20	2.81	17.20	16.00	2.75	0.30	0.08	2.20	0.32
7	MTPMD 7	63.21	36.75*	7.26	3.01	16.85	16.8*	2.70	0.30	0.07	2.20	0.30
8	MTPMD 11	62.91	37.05	7.25	2.86	16.82	16.85*	2.69	0.28	0.06	2.16	0.28
9	MTPMD 12	64.26*	35.70	7.50*	2.96	17.10	16.90*	2.74	0.30	0.08	2.24	0.29
10	MTPMD 13	63.71	36.25	7.25	2.91	17.20	16.00	2.75	0.31	0.08	2.23	0.33
11	MTPMD 14	62.56	37.40*	7.46*	3.01	17.15	15.00	2.74	0.31	0.08	2.20	0.32
12	MTPMD 15	62.91	37.05*	7.35	3.06	17.15	16.50*	2.74	0.29	0.08	2.20	0.30
13	MTPMD 17	63.63	36.33*	7.26	3.16	17.20	17.30*	2.75	0.33*	0.08	2.29*	0.31
14	MTPMD 19	64.36*	35.60	7.30	2.96	17.02	15.00	2.72	0.31	0.07	2.20	0.30
15	MTPMD 21	64.26*	35.70	7.35	2.91	17.18	16.00	2.75	0.30	0.08	2.23	0.32
16	MTPMD 22	64.71*	35.25	7.39	3.01	17.05	17.00*	2.73	0.30	0.07	2.24	0.33
17	MTPMD 23	65.41*	34.55	7.30	3.26*	16.97	17.30*	2.71	0.30	0.07	2.20	0.31
18	MTPMD 24	65.56*	34.40	7.25	2.86	16.98	16.90*	2.72	0.32	0.08	2.26	0.31
19	MTPMD 25	65.91*	34.05	7.50*	2.81	17.05	15.90	2.73	0.31	0.06	2.24	0.30
20	MTPMD 26	62.41	37.55*	7.40	2.96	16.95	16.00	2.71	0.33*	0.08	2.19	0.29
21	MTPMD 29	64.85*	35.11	7.38	3.01	17.12	16.00	2.74	0.31	0.07	2.22	0.30
22	MTPMD 30	65.11*	34.85	7.26	2.91	17.25	17.50*	2.76*	0.34*	0.09*	2.30*	0.33
23	MTPMD 32	63.31	36.65*	7.40	3.11	16.85	16.00	2.70	0.31	0.08	2.21	0.32
24	MTPMD 34	62.91	37.05*	7.37	3.06	16.89	15.40	2.70	0.31	0.08	2.19	0.30
25	MTPMD 39	63.45	36.51*	7.25	3.01	17.20	15.20	2.75	0.32	0.08	2.20	0.30
26	MTPMD 40	64.36*	35.60	7.35	2.96	16.99	15.80	2.72	0.30	0.07	2.27*	0.31
27	MTPMD 42	64.40*	35.56	7.50*	3.61*	17.05	17.00*	2.73	0.33*	0.08	2.26	0.33
28	MTPMD 43	65.11*	34.85	7.28	2.86	17.10	15.40	2.74	0.30	0.08	2.25	0.32
29	MTPMD 44	64.59*	35.37	7.39	2.91	17.11	16.10	2.74	0.31	0.08	2.24	0.30
30	MTPMD 46	63.21	36.75*	7.36	3.21*	17.20	16.20	2.75	0.29	0.07	2.20	0.30
	Mean	63.95	36.00	7.34	3.01	17.06	16.25	2.73	0.31	0.08	2.23	0.31
	SEd	0.08	0.11	0.04	0.09	0.11	0.12	0.02	0.01	0.01	0.02	0.01
	CD (0.05)	0.15	0.22	0.08	0.18	0.21	0.25	0.03	0.02	0.01	0.04	0.03

*Significant at 5% level

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Performance of Promising Okra Varieties and Fertilizers under Fruit Tree based Agroforestry Systems

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Keywords: Agroforestry, fruit tree, *Abelmoschus esculentus*, temperate, fertilizer, organic farming

1. Introduction

Fruit-tree-based agroforestry systems have only been modestly studied, especially in terms of quantification of biophysical interactions occurring in mixtures of fruit trees and crops (Bellow, 2004). In Himachal Pradesh temperate fruit trees such as apple, apricot, peach, pear and plum are most commonly used in agroforestry systems. Crops diversification from cereal-based cropping to vegetables is gaining momentum in accordance with prevailing agroclimatic conditions. Higher production of okra (*Abelmoschus esculentus* L. Moench) crop is possible by the cultivation of varieties or hybrids which show remarkable enhanced returns, compared to other cultivars grown at same climatic conditions and inputs applied (Javed et al 2009). The present production system has endangered our health and environmental security due to abundant use of chemical fertilizers and pesticides. Organic farming has been used to develop an alternative eco-friendly technology for sustainable vegetable production.

2. Materials and methods

Experiment was conducted in the experimental field of the Department of Silviculture and Agroforestry, Dr. YSP University of Horticulture and Forestry, Nauni, Solan (H P) during June 2020. The design used for the experiment was Randomized Block Design and treatment combinations include 2 tree components: apricot and pear), 2 planting condition: Inside and outside canopy), 3 Okra varieties (Kranti, Nauni P-8, and Tender), 3 nutrient and fertilizer doses *viz*. NPK + FYM (75:50:50 NPK Kg ha^{-1} + FYM @15 t ha^{-1}), Jeevamrut (500 litres ha^{-1}), FYM (15 t ha^{-1}). The plot size was 2 x 1m. Varieties were sown at a spacing of 45 x 15 cm. Open plots were also subjected to same fertilizer doses. The growth parameters of trees as well as vegetable crops were taken respectively during the two years.

3. Results and discussion

Pooled data of both the years (2020-2021) revealed that among different systems (agroforestry systems and open conditions), maximum number of nodes per plant (10.41), internodal length (11.76 cm), no. of fruits per plant (11.53), fruit weight (12.07 gm) and yield (83.25 q ha^{-1}) were found in open conditions and minimum no. of nodes per plant (8.95), internodal length (10.21 cm), no. of fruits per plant (10.07), fruit weight (10.79 gm), yield (72.38) were found in apricot based agroforestry system. These results are in accordance with Bhusara et al (2018) while studying the performance of different okra varieties under different spacings of *Melia composita* based agroforestry system and found that varieties performed better under open conditions as compared to agroforestry systems.

Examination of data also showed that among different varieties (Kranti, Nauni P-8, Tender) of okra, Nauni P-8 variety showed maximum number of nodes per plant (10.43), internodal length (11.76 cm), no. of fruits per plant (11.51), fruit weight (11.98 gm) and yield (82.10 q ha^{-1}) and minimum was found in Kranti variety. Different fertilizer doses revealed that NPK + FYM (75:50:50 NPK + FYM 15 t ha^{-1}) performed significantly better than rest of the fertilizers used. The maximum number of nodes per plant (10.34), internodal length (11.96 cm), no. of fruits per plant (11.69), fruit weight (12.32 gm) and yield (85.11 q ha^{-1}) and minimum when sole FYM @15 t ha^{-1} was incorporated as depicted in Table 1

References

Bellow JG 2004. An evaluation of tree crop interactions and socioeconomic characteristics in fruit tree based agroforestry system in western highlands of Guetmala. Ph.D. Thesis, University of Florida. 170p.

Bhusara JB, Dobriyal MJ, Thakur NS, Gunaga RP and Tandel MB 2018. Performance of okra (*Abelmoschus esculentus* L. Moench) under different spatial arrangements of *Melia composita* based agroforestry system. *International Journal of Current Microbiology and Applied Sciences* **7**:3533-3542.

Javed H, Aziz MA and Leghari RAK. 2009. Resistance in different okra cultivars against American bollworm (*Helicoverpa armigera* Hub.). *Journal of Agricultural Research* **47**:433-438.

Table 1. Effect of systems, varieties, and fertilizer doses on okra (*Abelmoschus esculentus*) varieties

Treatments	No. of nodes plant^{-1}			Internodal length (cm)			No. of fruits plant^{-1}			Fruit weight (gm)			Yield (q ha^{-1})		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
Systems															
Apricot	8.99	8.90	8.95	10.07	10.36	10.21	10.06	10.09	10.07	10.67	10.91	10.79	71.46	73.29	72.38
Pear	9.58	9.63	9.60	11.04	11.58	11.31	11.04	11.07	11.05	11.30	11.43	11.37	76.35	78.90	77.63
Open	10.08	10.74	10.41	11.52	12.01	11.76	11.52	11.54	11.53	12.01	12.13	12.07	80.46	86.03	83.25
SE(m)	0.13	0.15	0.14	0.11	0.14	0.11	0.15	0.15	0.15	0.16	0.17	0.16	1.33	1.50	1.34
$CD_{(0.05)}$	0.39	0.44	0.40	0.31	0.39	0.33	0.43	0.43	0.43	0.46	0.50	0.46	3.79	4.27	3.82
Varieties															
Kranti	8.99	9.18	9.08	10.80	11.18	10.99	10.05	10.07	10.06	10.50	10.80	10.65	70.18	72.74	71.46
Nauni P-8	10.29	10.57	10.43	10.93	11.33	11.13	11.50	11.52	11.51	11.92	12.04	11.98	79.72	84.48	82.10
Tender	9.37	9.53	9.45	10.90	11.43	11.17	11.08	11.10	11.09	11.54	11.63	11.59	78.37	81.01	79.69
SE (m)	0.13	0.15	0.14	0.11	0.14	0.11	0.15	0.15	0.15	0.16	0.17	0.16	1.33	1.50	1.34
$CD_{(0.05)}$	0.39	0.44	0.40	NS	NS	NS	0.43	0.43	0.43	0.46	0.50	0.46	3.79	4.27	3.82
Fertilizers															
NPK + FYM	10.15	10.53	10.34	11.82	12.11	11.96	11.68	11.70	11.69	12.27	12.37	12.32	83.88	86.33	85.11
Jeevamrut	9.68	9.85	9.76	10.87	11.27	11.07	10.99	11.01	11.00	11.32	11.48	11.40	76.51	80.33	78.42
FYM	8.82	8.89	8.85	9.94	10.56	10.25	9.97	9.99	9.98	10.38	10.63	10.50	67.87	71.57	69.72
SE (m)	0.13	0.15	0.14	0.11	0.14	0.11	0.15	0.15	0.15	0.16	0.17	0.16	1.33	1.50	1.34
$CD_{(0.05)}$	0.39	0.44	0.40	0.31	0.39	0.33	0.43	0.43	0.43	0.46	0.50	0.46	3.79	4.27	3.82

2.22/T_2-88

Litter Decomposition as Supporting Services from Multifunctional Agroforestry

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Keywords: Multifunctional agroforestry, litter, decomposition, half-life

1. Introduction

Litter decomposition plays an important role maintaining soil fertility in terms of nutrient cycling and soil organic matter and is highly influenced by soil organisms, chemical nature of the litter and environmental conditions.

2. Materials and methods

Freshly fallen senescent leaves of seventeen tree species were collected from multifunctional agroforestry model during November to February (Litterfall season). Twenty grams of litter samples of each tree species were packed into nylon mesh bags of dimension 20 X 20 cm. A total of 153 bags were prepared and placed in litter floor. Three bags of each species were retrieved once in every three months (90, 180, 270 and 360 days) and processed in laboratory for further analysis. The litter bags were carefully washed in water. The residual masses were oven dried at 70-80^{o}C for 48 hours and weighed to reach constant weight. The residual mass loss of each species, half-life period and decay constant were calculated.

3. Results and discussion

The decay constant (k) and initial nutrient content of leaf litter varied significantly throughout the year and across species (P<0.001). Lower mass loss (%) was recorded in *Calophyllum inophyllum* (38.58 ± 2.16), and *Pterocarpus santalinus* (34.61 ± 2.86). Half-life period indicates that *C. inophyllum* takes 3.50 year while *Neolamarckia cadamba* will take only 0.99 years for decomposition of 95 per cent of leaf litter. The worked out *k* value followed the order of *N. cadamba* < *Tectona grandis* < *Annona muricata* < *Moringa oleifera* and this may be due to higher litter quality. Decay constant varies from species to species and micro-climatic variation within a region may also influence the same (Verhoef and Gunadi, 2002; Hossain et al 2011).

References

Hossain M, Siddique MRH, Rahman MS, Hossain MZ and Hasan MM 2011. Nutrient dynamics associated with leaf litter decomposition of three agroforestry tree species (*Azadirachta indica, Dalbergia sissoo,* and *Melia azedarach*) of Bangladesh. *Journal of Forestry Research* **22**(4):577-582.

Verhoef HA and Gunadi B 2002. Decomposition dynamics and nutrient flow in pine forest plantation in Central Java. **In:** Management of Tropical Plantation-Forests and Their Soil Litter System, Science Publishers.173-211.

2.23/T_2-90

Effect of Different Spacing of Eucalypts (*Eucalyptus tereticornis*) Based Agroforestry System on Performance of *Rabi* Field Crops

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Keywords: Edaphic conditions, Eucalyptus, organic carbon, *rabi* crops and spacing

1. Introduction

Haryana is agrarian state carrying forward with intensive and mechanical agriculture, thusly, Forest cover limited to 1603 km^2 which makes 3.63% of its geographical area. Substantially, there is need to integrate trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. Agroforestry currently meets 50% of the demand for fuel wood, 60% to 70% of the demand for small timber, 70% to 80% for plywood, 60% of the raw material for paper pulp, and 9-11 % of the demand for green fodder, in addition to meeting the subsistence needs of households for grain, fruit, fibre, medicine, and so on. Growing field crops in the available space is the demand of the present production system. Hence the study was designed to see the effects of eucalypts tree spacing system on growth, yield attributes and yield and benefit cost ratio of wheat, barley and raya crops.

2. Material and methods

The present study was conducted at the Research Farm, Department of Forestry, CCS HAU, Hisar, The plantation of eucalyptus trees was done during October, 2018. In the *rabi* season, wheat (HD 2967) barley (BH 393) and raya (RH 30) raya were under eucalyptus based agro forestry system during 2020-21. There were three replications in the experiment with randomized block design.

3. Results and discussion

Yield intercrops was maximum under control (sole). Among agroforestry systems, yield of wheat, barley and raya (41.65, 37.46, and 18.15 q/ha, respectively) were found maximum under 9 x 3 m and 8 x 3 m (41.15, 37.39 and 18.03 q/acre, respectively).

Table 1. Yield and B:C ratio of wheat, barley and raya under the influence of eucalypts based agroforestry system

Tree spacing (m)	Wheat		Barley		Raya	
	Grain yield (q/ha)	B:C ratio	Grain yield (q/ha)	B:C ratio	Grain yield (q/ha)	B:C ratio
6 × 3	34.42C	1.09	32.69C	0.98	14.36C	1.32
7 × 3	37.24C	1.18	34.36C	1.03	16.12C	1.49
8 × 3	41.15B	1.30	37.39B	1.12	18.03B	1.66
9 × 3	41.65B	1.32	37.46B	1.13	18.15B	1.67
Control	52.08A	1.64	42.25A	1.27	20.58A	1.90
CD at 5%	5.33		3.04		2.35	

Higher yield under 9 × 3 and 8 × 3 m spacing may be attributed to broader spacing more light and nutrient availability and less competition for moisture among the field crops and tree crop. Deep-rooted plants consume more deep soil moisture than conventional cropland due to their well-developed and deeper root systems and higher evapotranspiration rates (Zhang et al 2018; Arora et al 2021). Maximum benefit cost ratio was estimated in raya under 9 × 3 m tree spacing (1.67) and 8 × 3 m (1.66) as compared to wheat (1.32), barley (1.13) under 9 × 3 m tree spacing. The tree spacing system 9 × 3 m and 8 × 3 m were found more economical as compared to other tree spacing system. This might be due to the reason of higher prices of grain of raya as compared to wheat and barley resulting in higher benefit cost ratio.

References

Arora R, Sharma V, Sharma S, Maini A and Dhaliwal SS 2021. Temporal changes in soil biochemical properties with seasons under rainfed land use systems in Shiwalik foothills of northwest India. *Agroforestry Systems* **95**(8): 1479-1491.

Zhang Z, Li M, Si, B and Feng H 2018. Deep rooted apple trees decrease groundwater recharge in the highland region of the Loess Plateau, China. *Science of the Total Environment* **622**: 584-593.

2.24/T_2-91

Agroforestry Production Management in Central Himalaya, India

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Keywords: Agroforestry, climate change, diversified production, Himalaya, Perennials

1. Introduction

Agroforestry systems are based on the principle of optimum utilization of natural resources. Agrihorticulture, silvihorticulture, hortipastoral, and silvipastoral systems are diversified land use options in the hill region. These agroforestry systems play vital role in the livelihood of the hill people (Yadav et al 2021). Globally, Agrihorticulture that includes cultivation of annual agricultural crops together with fruit trees is an elite and distinctive practice for diversified production. The farmers plant fruit trees and retain naturally grown fodder trees in agricultural fields as associated crops in the Indian Himalaya (Yadav et al 2019) which are prevalent in the region.

2. Material and methods

The study on agroforestry systems were conducted at experimental farm Hawalbagh (29°36′N and 79° 40′ E, 1250 m amsl) of ICAR-VPKAS, Almora, India. Agri-horticultural, silvi-horticultural, horti-pastoral and Silvipastoral systems were studied. Growth and yield of annual and perennial components were recorded and subjected to statistical analysis as per randomised block design.

3. Results and discussion

In fruit-based agrihorti system four fruit crops, hill lemon, pear, plum, and apricot were planted with soybean in *kharif* and dual-purpose wheat during *rabi* season, without significant effect on grain yield. Study in an agrihorti system revealed that ragi and soybean during *kharif* and wheat and lentil during *rabi* can be grown successfully with peach and pecannut tree without significant reduction in the yield of the crop. Under *Grewia*, *Quercus*, *Bauhinia* and *Celtis*, turmeric variety (RCT-1) yielded between 139 and 175 q/ha. While, on sloping land RCT-1 yielded from 86 to 135 q/ha under different fodder trees, however, under chirpine yield was 102 q/ha. Under *Quercus leucotrichophora* Swarna 183 q/ha and Pant Pitabh 177 q/ha yield was obtained.

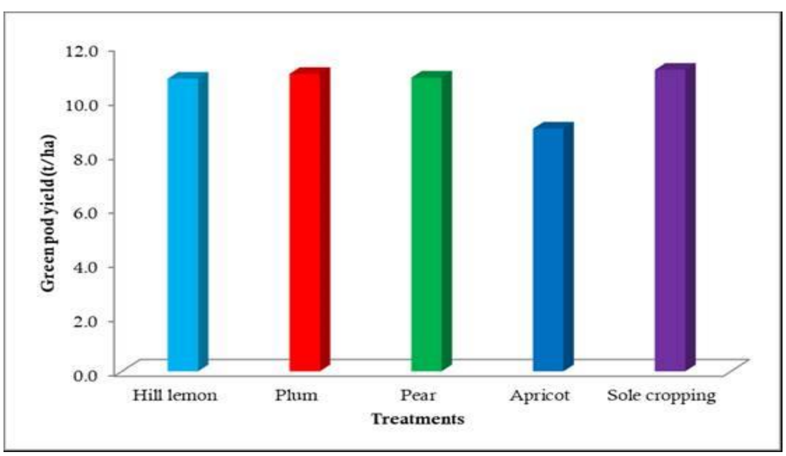

Figure 1. Green pod yield of pea under different fruit trees and in sole cropping

Winter and rainy season grasses under peach-based hortipastoral system produced 203 and 272 q/ha green forage, respectively on marginal land. Five trees i.e., *Grewia*, *Quercus*, *Bauhinia*, *Melia* and *Morus* with grass, *Setaria* was tested under the silvipastoral system. *Morus alba* yielded significantly higher green biomass (3,625 kg/ha) than others and *Setaria* produced green forage (7000 kg/ha). Therefore, agroforestry is a set of land use alternative for resource poor farmers that can provide increased values with reduced risks in the rural areas. Agroforestry is a climate resilient land use alternative, which can provide augmented values and reduced risks to resource poor farmers. The poor farmer will obtain diversified products i.e., food, fruit, fuel that enhance land productivity with round the year income generation and will strive to climate change with positive effect on the environment (Yadav et al 2021). Therefore, agroforestry should be more popularized through extension programmes in the rural areas.

References

Yadav RP, Bisht JK, Mondal T, Meena VS, Pandey BM, Mishra PK, Pattanayak A and Kant L 2021. Diversified climate resilient pecan (*Carya illinoinensis* (Wangenh.) K. Koch) based sustainable agroforestry improves livelihood and returns in Indian Himalaya. *Applied Ecology and Environmental Research* **19**(2):1309-1323.

Yadav RP, Gupta B, Bhutia PL, Bisht JK and Pattanayak A 2019. Biomass and carbon budgeting of land use types along elevation gradient in Central Himalayas. *Journal of Cleaner Production* **211**: 1284-1298. DOI: 10.1016/j.jclepro.2018.11.278

2.25/T_2-92

Biomass Production and Carbon Stock Assessment of Neem based Agroforestry in Central India, Jhansi

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1. Introduction

Bundelkhand region of Central India is characterised by undulating topography, high drought frequency, low fertility, lower soil depth, poor water retention capacity, lower organic matter and surface crust formation (Yadav et al 2022). The region falls in semi-arid and sub-tropical climate. Neem based Agroforestry system is most commonly cited in the region that helps in establishing earthen structures and mediates micro-climate. Tree is deciduous and enriches soil besides disinfecting it and used in urea coating. The biomass in woods is a paramount indicator of vegetation coverage, healthy environment and stores a large amount of the carbon. The objective of the present study was to estimate biomass and biomass carbon and soil carbon stock of a neem based agroforestry system central India, Jhansi.

2. Material and methods

The study was carried out in a neem- agroforestry plantation at Bhojla plantation site of Rani Lakshmi Bai Central Agricultural University, Jhansi. The site is situated between 25^0 30'-25' 32^0 N latitude and 78^0 32'-78' 34^0 N longitude with an altitude of 272 m above mean sea level. The area is semi- arid with the average rainfall of the area is around 867 mm. The present study was conducted in an already established two years old plantation of *Azadirachta indica* planted at a spacing of 5 m x 6 m. The measured biomass was converted to biomass C by multiplying biomass with a factor of 0.50. Recorded data was subjected to statistical analysis in randomised factorial design.

3. Results and discussion

Soil organic C, soil organic matter, available nitrogen, and soil C stock decreased, whereas bulk density increased with increasing distance from tree stem. Among different neem and crop combinations maximum soil organic C (0.57%), soil organic matter (0.99%) and available nitrogen (0.049) were recorded in neem + broad bean. Higher soil organic C (0.54%), soil organic matter (0.94%) and available nitrogen (0.047%) were recorded under neem based agroforestry as compared to sole cropping.

Table 1. Biomass (Above ground, below ground, and total), and biomass C (above ground, below ground and total) of neem tree, soil C stock and total C (soil+neem) as influenced by different treatments

Treatment	AGB	BGB	TB	AGC	BGC	TBC	Soil C stock	Total C stock (Soil+Vegetation)
Neem + Jack bean	2.65	0.68	3.34	1.32	0.34	1.67	24.16	25.83
Neem+ Broad bean	6.15	1.60	7.75	3.08	0.80	3.87	24.47	28.89
Neem + Grass pea	4.24	1.10	5.34	2.12	0.55	2.67	24.12	27.08
Neem+ Lentil	8.98	2.33	11.32	4.49	1.16	5.66	24.14	29.91
Neem+ Chick pea	5.29	1.37	6.66	2.64	0.68	3.33	23.84	27.55
SE(m)	1.11	0.29	1.40	0.55	0.14	0.70	0.10	0.67
C.D.	3.31	0.86	4.17	1.65	0.43	2.08	0.31	2.01

Note: AGB-Above ground biomass, BGB- Below ground biomass, TB- Total biomass, AGC- Above ground biomass carbon, BGC- below ground biomass carbon, TBC- Total biomass carbon

Among neem and crop associations the bulk density was more in neem + jack bean plots (1.59 g/cm^3), whereas between growing situations higher bulk density was in sole cropping (1.69 g/cm^3). Soil carbon stock was highest in neem + broad bean combination (24.48 Mg C/ha) than rest of the combinations and it was also higher under neem (24.15 Mg C/ha) as compared to sole cropping. The total neem biomass, total biomass C and total C were highest in neem + lentil plots (11.32, 5.66 and 29.91 Mg/ha), respectively compared to other plots. Similar trend was observed for aboveground and belowground biomass and biomass C. Hence agroforestry systems are good sink of the C.

Reference

Yadav RP, Tiwari P, Kumar R, Dobriyal MJ and Pandey AK 2022. Neem Based Agroforestry. **In:** Nurturing the Neem (*Azadirachta indica*) for Nature and Livelihood Security (AK Pandey, MJ Dobriyal & RP Yadav, eds), Technical Bulletin No.: CHF-6, 67-91, Rani Lakshmi Bai Central Agricultural University, Jhansi-284003, India.

2.26/T_2-93

Evaluation of *Piper betle* performance under *Gmelina arborea* based agroforestry system in Madhya Pradesh, India

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Keyword: Agroforestry, *Piper betle*, *Gmelina arborea, Zingiber officinale and Asparagus racemosus*

1. Introduction

Piper betle L. (Betle vine) a shade loving medicinal climber was introduced for the first time under tree based cropping system of *Gmelina arborea* Roxb. during 2017. An experiment was conducted under 8 year old *G. arborea* based Agroforestry system established at Tropical Forest Research Institute, Jabalpur, Madhya Pradesh. The *P. betle* climber requires hot and humid condition, so tree shade gave perfect condition for its growth. The other traditional spices like *Curcuma longa* (Turmeric), *Zingiber officinale* (Ginger) *and Asparagus racemosus (*Satawar*)* were also intercropped under this system.

2. Material and method

During the study period, tree - crop compatibility was assessed by monitoring growth, yield and insect-pest management periodically to standardize betle farming under the system. The fresh 'Paan' were harvested from the field after 8 months of raising which fetches Rs. 1/per leaf, while oil was extracted from the damaged and yellow leaves. The quantity of piper oil extracted from intercrop and in sole crop was also assessed and no significant variation was observed. The oil is used for treatment of digestive and respiratory disorders besides curing fungal infection on skin, gum problems and fighting bad breath**.**

3. Results and discussion

The growth was better when intercropped with *G. arborea* (T_1) and yield was significantly higher (in term of climber height, No. of leaves, size of leaves, quality of leaves) than that of Control (*P. betle*) T_2 followed by T_3 *i.e. P. betle* + C. *longa + Z. officinalis* under the system. The Piper oil was extracted from the betle leaves and twigs as well and data revealed that maximum oil (1% per Kg) content is found under the agroforestry system as compared to the sole crop (0.08% / 1kg) and the yield increased as the plant grows. This value-added product has potential to generate Rs.25000 per liter revenue and from 'Paan' leaves (@ Rs. 1 / leaf).

2.27/T_2-95

Silvipastures for Augmenting Fodder Production and Climate Change Mitigation Potential in Semi-Arid India

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1. Introduction

Semi arid zones in India are facing severe scarcity of quality fodder which is negatively impacting the livestock productivity in the zone. As almost 80% people in the zone depend on livestock for their livelihood security, thus meeting out quality fodder demand in the region is very crucial to support local livelihood. Moreover, these regions have poor adaptive capacity to climate change due to poor vegetation cover which points out towards creating carbon dioxide sinks in the region via enhancing vegetation cover. In such case scenario, silvipasture systems (SPs) are viable option that can provide round the year fodder for livestock and act as a carbon sink by storing huge amount of atmospheric carbon dioxide in biomass. Moreover, these SPs can be easily established on non arable and degraded land in semi arid zones of India. Thus, the present investigation was carried out at ICAR-IGFRI, Jhansi, during the year 2019-2020 in 10 year old SPs to unravel fodder production and biomass carbon storage potential of SPs.

2. Material and methods

The three tree species *viz*. *Acacia nilotica*, *Ficus infectoria* and *Morus alba* in combination with three grass species (*Panicum maximum, Cenchrus ciliaris* and *Chrysopogon fulvus*) were studied for their fodder production and biomass carbon storage potential. Fodder production potential in grasses and trees was calculated on per hectare basis and trees were imposed to 30% canopy pruning. Total carbon stock (Below and above ground) in trees and grasses was calculated by multiplying the respective dry matter with a conversion factor of 0.50 (IPCC 2006) and was added to calculate system biomass carbon storage potential. The data were analyzed statistically and mean values were compared at the P=0.05 level of significance using values for critical difference (CD).

3. Results and discussion

Green fodder biomass production potential in grasses was found to be maximum in *P. maximum* (29.31 t/ha) followed by *C. fulvus* (18.49 t/ha) and *C. ciliaris* (11.39 t/ha) with different tree combination. Whereas, trees species were found capable of providing 3-5 ton/ha of green top feed to livestock during lean period. Further, this SPs stored 11.08 t C/ha to 19.66 t C/ha in its vegetation biomass (Trees + grasses) under various tree grass combinations. Thus, this system is capable of providing quality fodder under semi-arid conditions, where the livelihood of most of the people depends on livestock sector. Besides this, the system is capable of mitigating climate change by storing huge quantities of atmospheric carbon dioxide in its below and above ground biomass. Therefore, establishing SPs in semiarid zone can prove as a boon for augmenting fodder production and climate change mitigation potential in semiarid India.

Reference

Intergovernmental Panel for Climate Change (IPCC) (2006). Task Force on National Greenhouse Gas Inventories.

2.28/T_2-116

Agroforestry Model for Livelihood and Increasing the Farm Income in Vidarbha, Akola District, India

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Keyword: Agroforestry, livelihood, farm income, agri-silviculture, saline soil

1. Introduction

Forest cover is decreasing at alarming rate. Its mandatory for us to increase tree cover area. Planting trees in farms is part of Agroforestry. Agroforestry is planting of trees, with agriculture crops for their direct and indirect benefits.

2. Material and methods

The study was conducted in village Kanadi, district Akola. Two methods were used; Primary data collection and Secondary data collection. In Primary data collection, conduction of participatory rural appraisal, survey techniques and other data collection methods were used. In secondary data collection method, records and official books from government officials was compiled and analysed. All the required necessary data to introduce the agroforestry system was obtained directly through survey, around 60 families were questioned. Based on analysed data a suitable agroforestry system was introduced.

Table 1. Agroforestry system and their benefits

Agroforestry system	Species	Economic and other Benefits
Agrisilviculture system	Teak, Bamboo, Nivdung, + seasonal Agri crop	Ecological as well as economic benefits Teak gives economic benefits around ₹45,50,000 to 97,00,000 after maturation in 1 acre in 20 to 25 years of rotation. economic benefits of ₹ 22000 to 40,000 of agricultural crops in 1 acre for one crop season bamboo which will give economic benefits of ₹ 1,80,000 after maturation
Agrosilvopastoral	subabool, Siris, ber, shisam + seasonal Agri crop	pasture land development fodder crop Siris and other crops also provide shade and fencing. Decreasing the soil erosion of land by increasing the soil holding capacity.

3. Results and discussion

On the basis of the data collected and survey conducted with respect to the Social, economic and ecological conditions of the village. Two types of Agroforestry models/systems were introduced Agrisilviculture and Agro-silvopastoral. These systems may be attributed to agroclimatic conditions of the area & need of the farmers *i.e.* food, fodder, fuel wood & timber etc. The agroforestry Species which were introduced in Agroforestry systems are mainly teak and bamboo along with Seasonal agriculture crops like soya bean with other tree species like Nivdung, sagargoti, ber, *etc*. Teak has economic benefit from ₹ 4,50,000 To 9,70,000 with expense charges ₹ 35,000 to 75,000 soyabean has benefit of ₹ 22,000 to 40,000 and bamboo has Rs. 1,80,000 in one acre of field.

2.29/T_2-121

Impact of Plant Growth Regulators on Total Herbage Yield and Oil Content of Patchouli (*Pogostemon cablin*) in Karanj based Agroforestry System, Chhattisgarh plain, India

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Keywords: *Pogostemon cablin,* agroforestry, plant growth regulators, Karanj, herbage

1. Introduction

The amount of shade that medicinal plants growing underneath the canopy in forests and tree plantations receive has an effect on their growth and chemical composition. In comparison to monoculture cropping systems, attention has recently cantered on the diversified medicinal plant production system for optimizing resource utilization. When compared to sole crops of the same species grown on the same field, better resource management results in higher total intercrop yields (Oraon et al 2005).

2. Materials and methods

The field experiment was laid out at Herbal Garden of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), India, during 2020-21. Analysis of observations were taken on different variables was carried out to know the degree of variation among all the treatments. The pooled data was statistically analysed through randomized block design.

Table 1. Impact of plant growth regulators on total herbage (q ha^{-1}) and oil content in patchouli (*P. cablin*) in Karanj based agroforestry system

Treatments	Fresh weight	Dry weight	Oil content
T1: NAA@20 ppm	29.67	3.64	9.53
T2: NAA@40 ppm	27.38	2.99	8.49
T3: Miraculan @100ppm	32.55**	4.07	7.96
T4: Miraculan @300ppm	21.84	2.97	3.49
T5: GA@ 20 ppm	18.73	2.39	6.84
T6: GA@ 40 ppm	23.87	2.88	8.07
T7: Kinetin@200ppm	29.75**	3.20	9.91**
T8: Control	12.28	1.80	4.80
Mean	24.51	2.99	7.39
SEm	39.36	0.817	2.531
CV	25.598	30.206	21.537
CD@ 1%	NS	NS	3.867
CD@ 5%	10.988	NS	2.786

**Significant @ 5%; NS: Non significant

3. Result and discussion

The fresh weight of patchouli was recorded significantly higher with the treatment Miraculan @100 ppm (32.55 q ha^{-1}) and kinetin @200 ppm (29.75 q ha^{-1}) and the least were recorded with control (12.28 q ha^{-1}). The dry weight recorded non-significant among different treatments and the oil content was significantly higher with the treatment Kinetin @200 ppm (9.91 q ha^{-1}) and the least was recorded with control (4.80; Table 1).

Reference

Oraon P R, Yadava M S, Siddiqui M H. 2005. Comparative performance of agroforestry systems in Kumharia village of Ranchi district. *Indian J. Agroforestry* 7(2):19- 24.

2.30/T_2-122

Effect of Tree-Crop Combination on Growth and Yield of Cabbage and Maize with Poultry Excreta under Mulberry in Phayeng, Manipur, India

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Keywords*:* Growth, yield, mulberry, intercropping, cabbage, maize, poultry excreta

1. Introduction

Mulberry foliage is the sole food for the silkworm and its leaf is a major economic component in sericulture. Mulberry can also be grown as an intercrop as shade plants beside its pruned shoots are a good source of firewood. A field experiment was conducted to examine the effect of a tree-crop combination of cabbage and maize with *Morus alba* during 2020-2021 with the aim to know the growth and yield of two agricultural crops (*Brassica oleracea* var. Green hero and *Zea mays* L.) under a mulberry intercropping system with poultry excreta treatment (soil amendment).

2. Material and methods

Field experiment was conducted to examine the effect of a tree-crop combination of cabbage and maize with *M. alba* with the aim to know the growth and yield of two agricultural crops under a mulberry intercropping system with soil amendment. The distinctive tree-crop combinations were, cabbage + Morus with soil amendment (T_1); cabbage + Morus without soil amendment (T_2); maize + Morus with soil amendment (T_3); maize + Morus without soil amendment (T_4). The cabbage seedlings were transplanted and Maize seeds were sown at the spacing of 45 x 45 cm. The growth parameters of cabbage (height, diameter of cabbage fruit, number of leaves) and maize (plant height, no. of leaves per plant) were measured. The yield parameters of cabbage (head weight, head diameter and outer number of leaves) and maize (cob length, cob weight) were recorded at the time of harvesting.

3. Results and discussion

The average head weight and head size of cabbage per plant was higher in cabbage grown in T_1 (2.047kg ±0.056; 17.944cm) than cabbage grown in T_2 (1.425kg ±0.033; 15.389 cm). Comparably, maximum plant height and number of leaves were obtained in crops grown in T_3 (182.5 cm; 10.5) rather than T_4 (162.5 cm; 8.4). Better growth of both cabbage and maize was obtained in crops grown in plots with soil amendment (poultry manuring). The study revealed that soil amendment with locally available poultry excreta can significantly improve the yield of cabbage and maize under mulberry cultivation.

2.31/T_2-126

Performance of Turmeric (*Curcuma longa)* under *Eucalyptus tereticornis* based Agroforestry System in Plains of Chhattisgarh

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Keywords: Agroforestry, turmeric, *Eucalyptus tereticornis*, intercropping

1. Introduction

Turmeric is usually used as a spice, in cosmetic, coloring agent, flavoring and preservative, and also ascribed universally to its aromatic, stimulative and carminative properties. Commercially, it is traded as a spice, dye, oleo-resin and source of industrial starch. Turmeric has been reported to possess anti-inflammatory, hepatoprotective, antitumor, antiviral and anticancer properties, and used in treating gastrointestinal and respiratory disorders (Polasa et al 1991 and Anwarul et al 2006).

2. Materials and methods

Turmeric (*Curcuma longa*) was cultivated at three plants spacing viz; S-1 (50 x 50cm), S-2 (50 x 30cm) and S-3 (40 x 30cm) under Eucalyptus based Agroforestry system plantation (3 x 3m) and in open field *i.e.*, without tree, at research farm of IGKV, Raipur (C.G.) in 2017-18. The experiment was laid out in Factorial RBD with four replications in 48 plots of 2.5 x 2.5 m size.

Table 1. Yield parameter of turmeric (*C. longa*) Eucalyptus based Agroforestry system

Statistical parameters	**Fresh weight of Rhizome (q/ha)**	**Statistical parameters**	**Fresh weight of Rhizome (q/ha)**	**Statistical parameters**	**Fresh weight of Rhizome (q/ha)**
Cropping System (Cs)		**Variety**		**Spacing**	
Open (Cs_{-1})	225.79	Ranga (V_{-1})	196.06	50x50(S_{-1})	197.63
AFS (Cs_{-2})	149.80	Roma (V_{-2})	179.53	50x30(S_{-2})	175.76
				40x30(S_{-3})	190.00
SEm ±	4.41	SEm ±	4.41	SEm ±	5.40
CD (at 5%)	NS	CD (at 5%)	NS	CD (at 5%)	NS

3. Result and discussion

The fresh yield obtained from open field was 225.79 qha^{-1} while agroforestry system 149.80 qha^{-1} (reduced by 33.77%). In case of variety Ranga (V-1) produced maximum fresh yield of 196.06 qha^{-1} as compared to Roma (V-2) 179.53 qha^{-1}. In case spacing, S-1 produced maximum fresh yield (197.63 qha^{-1}). Agroforestry gave better results for growth parameters while open field gave better yield of turmeric crop. In agroforestry long term cultivation of shade loving crop always gave economical viable system.

References

Anwarul H G, Abdul J, Muhammad N and Kashif M 2006. Pharmacological basis for the use of turmeric in gastrointestinal and respiratory disorders. *Life Sci.* **76**: 3089-3105.

Polasa K, Raghuram T C and Krishna T P 1991. Turmeric (*Curcuma longa* L.) induced reduction in urinary mutagens. *Food Chem. Toxic*. **29**: 699-706.

2.32/T_2-127

Effect of Nutrients on Growth Performance of Turmeric [*Curcuma longa*(L)] under Karanj (*Pongamia pinnata*) based Agroforestry System

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Keywords: Turmeric, *Curcuma longa,* Karanj, agroforestry, nutrient, growth

1. Introduction

Turmeric (*Curcuma longa* L.) is an important sacred and ancient spice of India. It is a major rhizomatous spice produced and exported from India. Turmeric is an herbaceous perennial, native to tropical South-East Asia, belonging to the family zingiberaceae. In agroforestry system, higher production might be due to several growth factors like light or water or because of enhanced fertility of soil (Tokey 1997 and Samra et al 1999).

2. Materials and methods

The present study was carried out at Herbal Garden of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), India, during 2019-20. The experiment was conducted on Randomize Block Design (RBD) with 03 replications. 8 treatments were allocated in growth parameters *i.e.*, Plant height (cm), Number of tillers per plant and Number of leaves per plant.

Table 1. Effect of nutrient on growth parameters of turmeric under Karanj based agroforestry system

Treatments Details	Plant height (cm)	Number of tillers	Number of leaves pant^{-1}
T_1: 100 % inorganic	66.33	1.67	15.33
T_2: 100 % inorganic	64.67	1.67	12.67
T_3: 100 % inorganic	63.00	1.67	12.00
T_4: 75% inorganic + 25 % FYM	67.00	1.67	16.00
T_5: 50 % inorganic + 50 % FYM	69.67	1.67	17.33
T_6: 25 % inorganic + 75 % FYM	70.00	1.67	17.33
T_7: 100 % FYM	76.67	2.67	19.00
T_8: control zero fertilizer	61.00	1.00	9.00
SEm±	0.874	0.311	0.761
CD @ (P=0.05)	2.651	NS	2.309

3. Result and discussion

Among the different treatment, T_7 (100 % FYM) resulted in maximum plant height (31.00, 44.00, 74.67, 85.33 and 76.67 cm, respectively), maximum number of tillers per plant (3.33, 3.67, 3.67, 3.67 and 2.67, respectively), and maximum number of leaves per plant (10.67, 18.00, 26.67, 26.67 and 19.00, respectively), at 30, 60, 90, 120 and 150 DAP. While the minimum was recorded in treatment T_8 (control zero fertilizer). On the basis of present investigation, treatment T_7 stood better and followed by T_6 (25 % Inorganic + 75 % FYM).

References

Sharma Y M L 1987. Inventory and resources of bamboos, In: *Recent Research on Bamboos*, A.N. Rao, G. Danarajan and C.B. Sastry (Eds), Chinese Academy of Forestry and International Development Research Centre. pp. 14-27.

Tokey O P 1997. Poplar an economy booster and eco-friendly agroforestry tree. *Agroforestry News Letter* NRC for Agroforestry **9:** 2-3.

2.33/T_2-132

Effect of *Pongamia pinnata* Seed Source on Litter Quality and Decomposition under Agroforestry System

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Key words: *Pongamia pinnata* source, intercrops, safflower, seed yield

1. Introduction

Pongamia is one of the few nitrogen fixing trees containing 30-40 % oil in seed. The seeds are largely exploited for extraction of non-edible oil commercially known as 'Karanja oil', which is well known for its medicinal properties. Different Pongemia sources has variation in leaf litter quality parameters *viz.*, Nitrogen, Phosphorous, Potash, Magnesium, C:N ratio and ash content. The variation is influenced by genetic as well environmental factors.

2. Materials and methods

The experiment was carried out during *rabi* season of 2013-14 in Main Agricultural Research Station (MARS), UAS, Dharwad, India. Pongamia seed sources *viz.*, eleven sources RAK-103, RAK-106, RAK-11, RAK-90, RAK-22, RAK-05, RAK-89, MTP-I, MTP-II and MTP-III and DPS-4. Litter bag technique was used to study decomposition of Nitrogen, phosphorus, potassium and magnesium content in the residual litter. After digestion, N was determined in Kjeltec Auto 1030 Analyzer. For estimating phosphorus, potassium, calcium and magnesium samples were digested in 4:1 nitro-perchloric acid mixture. In the digest, phosphorus was determined by Vanado-molybdo-phosphoric yellow colour method using Spectromic 20-D. Potassium, magnesium and calcium were determined using Atomic Absorption Spectrophotometer.

3. Results and discussion

Table1. Chemical composition (%) of the fresh leaf litter material of different seed sources of *P. pinnata*

Seed sources	N	P	K	C	C:N	Mg	Lignin	Cellulose	Ash
T_1 - RAK-103	2.18	0.48	0.30	44.8	20.5	1.89	22.5	27.1	10.2
T_2 - RAK-106	2.04	0.81	0.39	43.3	21.2	0.98	25.9	31.2	18.2
T_3 - RAK-11	2.43	0.48	0.42	43.9	18.1	2.02	28.5	26.8	10.2
T_4 - RAK-90	2.26	0.84	0.62	34.3	15.2	2.95	34.9	25.6	25.1
T_5 - RAK-22	2.29	0.71	0.65	35.5	15.5	2.45	31.5	24.3	23.2
T_6 - RAK-05	2.62	0.49	0.29	41.5	15.8	1.59	26.8	26.0	11.5
T_7 - RAK-89	2.92	0.59	0.52	40.6	13.9	1.64	32.3	24.8	2.8
T_8 - MTP-I	1.86	0.51	0.51	46.3	24.8	0.96	39.4	33.7	3.8
T_9 - MTP-II	1.88	0.43	0.32	42.2	22.5	1.82	37.7	30.8	4.0
T_{10} - MTP-III	1.98	0.62	0.32	42.8	21.6	0.92	34.1	31.5	9.2
T_{11} - DPS-4	2.10	0.59	0.29	46.9	22.3	1.24	27.7	27.3	10.4
Mean	2.23	0.6	0.42	42.01	19.22	1.68	29.85	28.1	11.69

Nitrogen content was found to be maximum in T_7 RAK-89 (2.92 %), followed by T_6 RAK-05 (2.62 %) and lowest in T_8 MTP-I (1.86 %). C: N ranged from 15.2 % (T_4 - RAK-90) to 24.8 % (T_8 - MTP-I). Likewise the maximum lignin and cellulose was recorded in T_8 - MTP-I (39.4 %) and T_8 - MTP-I (33.7 %), respectively. Maximum ash content was recorded in T_4 - RAK-90 (25.1 %), followed by T_5 - RAK-22 (23.2 %). The difference in the decomposition pattern of Pongamia sources could be attributed to the initial chemical characteristics nitrogen, lignin and C/N ratio of leaf litter, which differed significantly among the Pongamia sources. Macroclimate, lignin and several factors control of litter decomposition rates (Meentemeyer 1978).

Reference

Meentemeyer V 1978. Macroclimate and lignin control of litter decomposition rates. *Ecology* 59, 465-472.

2.34/T_2-149

Influence of Tree Geometry on Growth and Yield of Mung Bean (*Vigna radiata* L.) under Gamhar (*Gmelina arborea* Roxb.) based Agroforestry System

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Keywords*:* Agroforestry, gamhar, industrial plantation, intercropping, mungbean, tree geometry

1. Introduction

Agroforestry is the integration of agriculture and forestry technology to provide diversified and productive land use systems. It is a multi-functional land use system that provides potential for economic gain, livelihood, nutrition, and improved health, as well as a more sustainable environment (Yadav et al 2022). They are found all across the globe primarily in the tropics, subtropics and even temperate regions across Asia, Africa, Europe, North America, South America and Pacific islands, though less studied scientifically (Viswanath et al 2018). This study is based on the trial of mung bean intercropped along with gamhar.

2. Material and methods

This investigation was carried out at gamhar-agroforestry plantation in Bhojla experimental farm. The site is situated between 25° 31' 1.6896" N - 25° 30' 58.6296" N latitude and 78° 33' 39.5028" E - 78° 33' 40.7736" E longitude with an altitude of 288 m above mean sea level. The area is semi- arid with the average rainfall of the area is around 867 mm. The effect of different spacing patterns *viz*., S_1- 5 x 5 m, S_2- 5 x 4 m, S_3- 5 x 3 m in 2 year old Gamhar plantation on mung bean was studied. The research included 7 treatments representing different tree spacings and cropped areas. Mung bean was cultivated between the rows of trees and its growth response and yield was calculated.

3. Results and discussion

The increment in height of gamhar was found maximum (0.295 m) in 5 x 3 m spacing with sole tree (Table 1). The highest increment in crown spread (0.996 m) was recorded in 5 x 4 m spacing with cropping. The gamhar showed maximum girth increment (9.42 cm) in 5 x 3 m spacing with cropping. The yield attributes like grain yield, straw yield and biological yield of mungbean was found to be maximum in sole cropping (0.730 t/ha, 2.179 t/ha, 2.909 t/ha, respectively) followed by 5 x 5 m spacing with cropping (0.674 t/ha, 1.964 t/ha, 2.638 t/ha, respectively). The harvest index of mungbean was observed maximum in 5 x 3 m spacing with cropping (26.13%) followed by 5 x 4 m spacing with cropping (25.87%). Study revealed significant differences among trees in terms of height, GBH (girth at breast height) and crown spread increment. The changes in yield and other parameters are attributed to the different pacing regimes.

Table 1. Different growth and yield parameters of tree and crop as influenced by various treatments

Treatment	Grain Yield	Straw Yield	Biological Yield	Harvest Index	Tree Height	Crown Spread	GBH
T1 (Sole Cropping)	0.730	2.179	2.909	25.08	-	-	-
T2 (5m x 5m, uncropped)	-	-	-	-	3.13	2.58	19.27
T3 (5m x 4m, uncropped)	-	-	-	-	4.19	2.83	21.96
T4(5m x 3m, uncropped)	-	-	-	-	3.71	2.62	18.73
T5 (5m x 5m, cropped)	0.674	1.964	2.638	25.62	4.90	3.32	26.48
T6 (5m x 4m, cropped)	0.666	1.910	2.576	25.87	5.95	3.90	30.21
T7 (5m x 3m, cropped)	0.615	1.745	2.359	26.13	4.95	3.34	25.44

References

Yadav R P, Tiwari P, Kumar R, Dobriyal M J and Pandey A K 2022. Neem Based Agroforestry. In: Nurturing the Neem (*Azadirachta indica*) for Nature and Livelihood Security (AK Pandey, M J Dobriyal & R P Yadav, eds), Technical Bulletin No.: CHF-6, 67-91, Rani Lakshmi Bai Central Agricultural University Jhansi-284003, India.

Viswanath S, Lubina P A, Subbanna S and Sandhya M C 2018. Traditional agroforestry systems and practices: a review. *Adv Agric Res Technol J*. *2*(1): 18-29.

2.35/T_2-151

Effect of Spatial Arrangement of Tree on the Performance of Black Gram (*Vigna mungo* L.) under Kadam (*Neolamarckia cadamba* Roxb.) Based Agroforestry System

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1. Introduction

Agroforestry is a land-use system that combines tree planting and crop/livestock farming in a symbiotic relationship. It can improve soil health, increase crop yields and provide numerous environmental benefits (Panchal et al 2017). One of the main components of agricultural forest systems is the spatial arrangement of trees, which has a significant impact on crop performance. Black gram is a major pulse crop grown in India, known for its high protein content and its adaptability to a wide variety of soil types. Kadam is a rapidly growing tree species that is widely used in agroforestry systems because of its ability to fix nitrogen and shade crops. The study focuses on assessing the role of tree geometry in agroforestry systems and its impact on crop performance. It will contribute to the development of more efficient and sustainable agricultural forestry systems that can improve farmers' livelihoods and contribute to the conservation of natural resources.

2. Material and methods

The present study was carried out in an already established two years old plantation of *Neolamarckia cadamba* at Bhojla experimental farm of Rani Lakshmi Bai Central Agricultural University, Jhansi. The trees are planted at three different spacing patterns viz., S_1- 5 x 5 m, S_2- 5 x 4 m, S_3- 5 x 3 m. The effect of different spacing of trees on Black Gram was studied. The experiment was laid out in RBD having seven treatments and four replications in which the treatments were randomly arranged in each replication. IPU 13-1 variety of black gram was selected for sowing. The difference in growth and yield parameters of crop in black gram at different distances from the tree was also studied.

3. Results and discussion

The configuration of trees had a substantial effect on the growth and yield of both crops and trees (Table 1). Among different tree-crop spacings, the sole cropping recorded the highest plant height (76.02 cm), number of trifoliate leaves (14.1), branches (12.45), and leaf area (59.21 cm^2), while intercropping (5 x 5 m) had lower values of height (73.87 cm), trifoliate leaves (13.92), branches (12.7), and leaf area (55.17 cm^2). The highest number of pods per plant (27.3) and seeds per pod (5.6) were observed in sole cropping of black gram, compared to spacing S_1 (5 m x 5 m) where the numbers were recorded as (26.4) pods per plant and (5.55) seeds per pod, respectively.

Additionally, a significant difference was noted in the growth of trees in the two-year-old plantation between cropped and uncropped areas. The trees in uncropped areas recorded higher height (5.01 m), diameter at breast height (29 cm), and crown spread (4.16 m) due to the lack of competition. The results are in confirmation with the results reported by (Kumar et al 2021). The study investigated that tree geometry affects black gram crop growth and yield in agroforestry systems. Sole cropping showed the highest performance, while intercropping with S_1 spacing had slight lower results. Trees in uncropped areas grew better. The study highlights the significance of considering tree arrangement in agroforestry to improve crop performance and create sustainable systems for farmers and resource conservation.

Table 1. Different growth and yield parameters of tree and crop as influenced by various treatments

Treatment	PH (cm)	TF	NB	LA (cm^2)	PP	SP	TH (cm)	TDBH (cm)	TCS (m)
T1 – *V. mungo* sole crop (5 x 5 m)	76.02	14.1	12.45	59.21	27.3	5.6	-	-	-
T2 – *N. cadamba* sole tree (5 x 5 m)	-	-	-	-	-	-	4.36	23.68	3.50
T3 - *N. cadamba* sole tree (5 x 4 m)	-	-	-	-	-	-	3.89	24.47	3.77
T4 - *N. cadamba* sole tree (5 x 3 m)	-	-	-	-	-	-	5.01	29	4.16
T5 - *N. cadamba* (5 x 5 m) + *V. mungo*	73.87	13.92	12.17	55.17	26.4	5.55	4.33	24.70	3.67
T6 - *N. cadamba* (5 x 4 m) + *V. mungo*	72.17	13.35	12.07	54.98	23	5.45	3.66	21.72	3.11
T7 - *N. cadamba* (5 x 3 m) + *V. mungo*	71.32	13.22	11.92	52.97	22.2	5.37	4.08	24.77	3.33

Note: PH- Plant height, TF- No. of trifoliate leaves, NB- No. of branches, LA- Leaf area, PP- No. of pods per plant, SP- No. of seeds per pod, TH- Tree height, TDBH- Tree diameter at breast height, TCS- Tree crown spread

References

Kumar AR, Prabakaran P and Sivasabari K 2022. Growth and yield performance of black gram (*Vigna mungo* L.) under malabar neem (*Melia dubia*) plantations in western zone of Tamil Nadu. *Legume Research-An International Journal* **45**(2): 182-188.

Panchal SJ, Thakur NS, Jha SK and Kumar V 2017. Productivity and carbon sequestration under prevalent agroforestry systems in Navsari District, Gujarat, India. *International Journal of Current Microbiology and Applied Sciences* **6**(9): 3405-3422.

2.36/T_2-158

Studies on Tree Geometry and its Effect on growth of Mung Bean under *Melia Dubia* Cav. based Agroforestry System

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1. Introduction

India has been in the forefront of agroforestry research ever since organized research in agroforestry started worldwide about 25 years ago. Considering the country's unique land-use, demographic, political, and sociocultural characteristics as well as its strong record in agricultural and forestry research, India's experience in agroforestry research is important to agroforestry development, especially in developing nations. Agroforestry has received much attention in India from researchers, policymakers and others for its perceived ability to contribute significantly to economic growth, poverty alleviation and environmental quality, so that today agroforestry is an important part of the 'evergreen revolution' movement in the country (Puri and Nair, 2004). *Melia dubia* is an indigenous, fast-growing and most favoured tree species, being promoted as an alternative to many exotic industrial tree species in India. It is amenable for pulp, pencil, packaging and plywood production. It has been widely cultivated by farmers in the southern states and to some extent in the central and North Indian states. *M. dubia* is proving highly beneficial to them in terms of monetary and other livelihood opportunities (Chavan *et al*., 2022)

2. Material and methods

This study was conducted in the Bhojla experimental farm's melia-agroforestry plantation. The location lies between latitude 25°31'02.9"N and 78°33'40.0"E longitude, at an elevation of 272 meters above mean sea level. The region is semi-arid, with an average rainfall of roughly 867 mm. The influence of several spacing patterns, namely S_1- 5 m x 5 m, S_2- 5 m x 4 m, and S_3- 5 m x 3 m, on mung bean was researched at the Forestry Research Farm, RLBCAU, Jhansi. Seven treatments representing various tree spacings and cropped areas. Mung bean was grown between the tree rows, and its growth response was calculated.

3. Results and Discussion

In the conducted experiment it was found that, plant height (78.3 cm), no. of root nodules per plant

Table 1. Growth parameters of tree and crop as influenced by various treatments

Treatment	Plant Height (cm)	No. of Root Nodules per plant	Dry Matter Accumulation (g/plant)	Tree Height (m)	Tree GBH (cm)	Crown Spread (m)
T1 (Sole Cropping)	78.3	5.6	41.79	-	-	-
T2 (5 m x 3 m, uncropped)	-	-	-	6.44	31.43	3.45
T3 (5 m x 4 m, uncropped)	-	-	-	5.29	27.04	3.14
T4(5 m x 5 m, uncropped)	-	-	-	5.55	26.42	3.09
T5 (5 m x 3 m, cropped)	74.62	4.87	26.98	6.07	31.41	3.55
T6 (5 m x 4 m, cropped)	75.84	4.77	23.47	5.92	28.91	3.07
T7 (5 m x 5 m, cropped)	77.25	4.8	21.96	5.50	26.97	3.17

dry matter accumulation (47.79 g) was significant in sole cropping and if we considered the tree attribute like tree height (6.44 m), tree girth at breast height (31.43 cm) is more in spacing S_1 (5 m x 3 m) uncropped while tree crown spread (3.55 m) was significant in spacing S_1 (5 m x 3 m) with cropping. The findings of this investigation indicated substantial variations in tree height, girth, and crown spread increment. The varying spacing regimes are responsible for the differences in growth and other characteristics.

References

Chavan SB, Uthappa AR, Sridhar KB and Kakade V 2022. Scientific techniques for *Melia dubia*-based agroforestry systems: an emerging indigenous tree species for wood-based industries in India. *Current Science* **122**(12): 1451.

Puri S and Nair PKR 2004. Agroforestry research for development in India: 25 years of experiences of a national program. *Agroforestry Systems* **61**: 437-452.

2.37/T_2-160

Impact of Human Wildlife Conflict on Livelihood of the People in Malrajura Village of Akola District (M.S.)

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Keywords: Human animal conflict (HWC), human death and injury, crop raiding

1. Introduction

Human - Wildlife Conflict (HWC) is defined as 'interaction between humans and wildlife where negative consequences, whether perceived or real, exists for one or both t iven India's ever-growing population, its ever-shrinking forests, and a host of other factors. For the sake of simplicity, and in a search for pragmatic solutions rather than scapegoats, this paper adopts a deliberately narrow scope; it defines human-wildlife conflict as instances where the actions of wild fauna cause damage to human beings or their property. This does not mean, and it should be taken to mean, that wildlife is ultimately responsible for these outcomes.

2. Materials and methods

The present study was conducted in the Malrajura village of Akola District Fig.1. According to Village Census 2011 information the location code or village code of Malrajura village is 530425. Malrajura (20.3886° N, 76.9614° E) village is in Patur Tehsil of Akola district in Maharashtra, India. It is situated 13km away from sub-district headquarter Patur (Tehsildar Office) and 41 km away from district headquarter Akola. As per 2009 stats, Malrajura village is also a Gram Panchayat. The total geographical area of village is 964 hectares. Malrajura has a total population of 1,820 peoples. There are about 408 houses in Malrajura village. Patur is nearest town to Malrajura for all major economic activities, which is approximately 13 km away. The normal annual rainfall over the district varies from about 740 mm to 860 mm. Approximately 90% of the population is engaged in agriculture with an average landholding 5 acre.

3. Results and discussion

Major crops such Soyabean, Tur, Wheat and Gram are being cultivated. Majority of respondents (50%) were small farmers whereas (30%) found to be the medium farmers followed by (15%) of them to be as semi-medium farmers and (5%) as marginal farmers. Majority of the respondents were having the primary occupation as agriculture (60%), followed by agriculture and labour (20%); whereas some of the respondents were engaged in agriculture and business (15%) and (5%) were engaged in agriculture and services. Majority of the respondents were categorized in the low income (50%) followed by very high income (25%) whereas others were categorized in middle income (15%) and high income (10%), respectively.

2.38/T_2-161

Nutrient Content and Uptake of Soybean (*Glycine Max* Meril) in Different Fertility Levels and Rhizobium Inoculation Under Guava based Agri horticulture System

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1. Introduction

Plant growth depends on the uptake of nutrients from a growing media. About 60% of the world's supply of vegetable protein and 30% of oil came from soybean seeds, which have about 40% protein and 20% oil respectively. In agri horticulture system horticulture plants (Guava, Beal, etc.) are preferred. The experiment conducted to study the "nutrient content, uptake and economics of soybean (*Glycine Max* Meril) on different fertility levels and rhizobium inoculation under guava based agri horticulture system.

2. Materials and methods

The field experiment was conducted at the Agriculture Research farm of Rajiv Gandhi South Campus, Barkachha (BHU) in kharif season 2018-19 in 12-year-old guava plantation with spacing 7×7 m. This region comes under (semi-arid eastern plain zone) agro-climatic zone III A. The soybean variety (JS-2029) was sown as intercrop with 80 kg per ha seed rate and spacing was 45×5 cm. The experiment was laid on Randomised complete block design with 5 treatments with 4 replications.

3. Results and discussion

The results indicates that the application of 50 kg N, 100 kg P_2O_5, 60 kg K_2O and 40 kg S kg/ ha with rhizobium inoculation significantly improved the nitrogen (N), phosphorus(P), potassium (K) and sulphur (S) content in seed and straw and their respective removal over control. This might be due to more nitrogen fixed by bacteria which in turn helped in better absorption and utilization of all the plant nutrients and of the highest fertility levels. Similar trends of results were reported by Jahangir et al (2009), Dhage et al (2014) that nutrient uptake of soybean increased with increasing fertilizer level. based on finding of study N, P, K and S content (%) and removal in seed and straw (kg/ ha) of soybean were significantly improved with fertility level of 50 kg N, 100 kg P_2O_5, 60 kg K_2O and 40 kg S ha per inoculated with rhizobium culture than control.

References

Dhage SJ, Patil VD and Patange MJ 2014. Effect of various levels of phosphorus and sulphur on yield, plant nutrient content, uptake and availability of nutrients at harvest stages of soybean [Glycine max (L.)]. *International journal of current microbiology and applied sciences* **3**(12): 833-844.

Jahangir AA, Mondal RK, Nada K, Sarker MAM, Moniruzzaman M and Hossain MK 2009. Response of different level of nitrogen and phosphorus on grain yield, oil quality and nutrient uptake of soybean. *Bangladesh Journal of Scientific and Industrial Research* **44**(2): 187-192.

2.39/T_2-185

Cucurbitaceous vegetable crops growth and yield performance in teak (*Tectona grandis* L.f.) based silvi-horticultural system

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Keywords: Cucurbitaceous crops, teak, Silvi-horticultural system, Yield

1. Introduction

Agroforestry is a sustainable land use system where agricultural crops are raised along with woody perennials for economic, environmental and social gain. Teak is a preferable multipurpose tree species adopted by farmers in the agroforestry system with various agricultural and vegetable crops. The present trial was carried out to find the growth and yield performance of cucurbitaceous vegetables as well as to utilize the interspace and sciophytic condition in a teak based silvi-horticultural system in South Gujarat condition.

2. Materials and method

The trial was carried out at College Farm, Navsari Agricultural University, Navsari, Gujarat, during summer season of 2016 and 2017. The experiment comprised of eight treatments *i.e.*, four cucurbitaceous vegetables grown under established teak plantation and as sole crop in open condition for these four crops with three replications in Randomized Block Design. Growth and yield parameters were taken for two years and statistically analyzed.

3. Results and discussion

Growing of various cucurbitaceous crops in sole cropping system resulted in significant increase in various growth as well as yield parameters as compared to growing cucurbitaceous crops under teak based silvi-horticultural system. Considering important yield parameters, recorded maximum average fruit weight in Bottle Gourd var. Local; fruit circumference in Bottle Gourd var. Local; whereas, marketable fruit yield, fruit yield, fresh weight of plant and dry weight of plant were noted significantly maximum in Smooth Gourd var. Pusa Chikni grown in sole cropping system and relatively less in teak based silvi-horticultural system. It is concluded that in the teak based silvi-horticultural system, out of four cucurbitaceous vegetable crops, anyone can be grown in South Gujarat conditions as their production is at par with each other and by considering their economics, producing higher net income in the agroforestry system than the sole crop.

Table 1. Yield parameters of Cucurbitaceous vegetable crops under teak based silvi-horticultural system

Treatments	Average fruit weight(g)			Fruit circumference (cm)			Marketable fruit yield (q/ha)		
	Yr-1	Yr-2	Pooled	Yr-1	Yr-2	Pooled	Yr-1	Yr-2	Pooled
T_1 : Bottle Gourd var. Local + *Tectona grandis* L.f.	352.21	340.38	346.30	20.43	20.13	20.28	89.13	89.07	89.10
T_2 : Ridge Gourd var. Pusa Nasdar + *Tectona grandis* L.f.	148.60	146.60	147.60	10.37	10.50	10.43	83.37	82.90	83.13
T_3 : Smooth Gourd var. Pusa Chikni + *Tectona grandis* L.f.	213.80	216.10	214.95	12.17	12.10	12.13	90.93	91.13	91.03

T_4 : Cucumber var. Local + *Tectona grandis* L.f.	126.90	127.46	127.18	8.37	8.20	8.28	82.07	82.23	82.15
T_5 : Bottle Gourd var. Local sole crop	385.60	392.76	389.18	22.23	21.23	21.73	172.97	171.27	172.12
T_6 : Ridge Gourd var. Pusa Nasdar sole crop	154.30	155.09	154.70	10.57	10.60	10.58	142.03	144.30	143.17
T_7 : Smooth Gourd var. Pusa Chikni sole crop	220.80	222.87	221.84	12.50	12.03	12.27	175.43	174.73	175.08
T_8 : Cucumber var. Local sole crop	132.90	132.89	132.90	8.50	8.53	8.52	140.33	141.93	141.13
S.Em.$\pm$	7.685	7.614	5.409	0.859	0.820	0.594	5.367	6.458	4.198
C.D. @ 5 %	23.04	22.83	15.91	2.58	2.46	1.75	16.09	19.36	12.35
S.Em.$\pm$ (YXT)	-	-	7.650	-	-	0.840	-	-	5.937
C.D. @ 5 % (YXT)	-	-	NS	-	-	NS	-	-	NS
C.V.%	6.14	6.08	6.11	11.32	11.00	11.17	7.62	9.15	8.42

2.40/T_2-199

Effect of Integrated Nitrogen Management on Growth and Yield of Okra Under Teak (Based Silvi-Horticulture System in South Gujarat

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Keywords: Agroforestry, nutrient management, vegetable crops, yield

1. Introduction

Agroforestry is one of the importance practices which can fulfill these basic needs of increasing population. South Gujarat's climatic condition is most suitable for growing teak and okra. Okra is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. It requires large quantities of both macro and micro nutrients for required economic yields. Nitrogen is important and play a key role in the production of both quantity and quality level in okra. Teak is one of the most valuable and importance tropical hardwood timber tree species and also holds the medicinal value therefore, meanly farmer preference to it for plantation. Therefore, the present study is intended to investigate the effect of integrated nitrogen management on growth and yield of okra under teak based silvi-horticulture system in South Gujarat.

2. Materials and methods

The field experiment was conducted during *summer* season of 2019 and 2020, at Navsari Agricultural University, Navsari, Gujarat, India. An experiment was designed in completely randomized block design with eleven treatment combinations Okra cv. GAO-5 was sown in the inter spaces of 23 year old teak plantation and recommended dose of fertilizer (RDF) 150:50:50 @NPK kg ha^{-1} applied to okra. Nitrogen from organic fertilizer applied full does initially while from chemical recommended dose of N was applied at 30 days interval in three split doses (*i.e*. 50-50-50 N kg ha^{-1}) in aqueous form of urea while phosphorus and potassium applied as basal dose. Suggested cultivation practice and cultural operations carried out in okra (Kumar and Choudhary, 2014). The recorded data of two years were statistically analyzed and treatment means were compared by using critical difference tests at 5% of probability and analysis of variance.

3. Results and discussion

All the growth and yield parameters were significantly affected by different INM treatments under teak based silvi-horticultural system and in open condition. Results of an experiment existing data are average of two years, significantly maximum plant height (65.99 cm), collar diameter (1.81 cm), number of branches per plant (2.05), fruit length (9.57 cm), number of fruits per plant (8.96), weight of fruit (124.58 g $plant^{-1}$) and fruit yield of okra (11.07 t/ha) were recorded in open condition when applied 75% RDN through neem coated urea + 25% RDN through vermicompost (T_{11}). It may be due to combine application of fertilizer improve available essential micro nutrients which promote growth and also yield attributes (Miller 2007). While, under teak based silvi-horticultural system, maximum plant height (56.43 cm), collar diameter (1.55 cm), number of branches per plant (1.90), fruit length (9.10 cm), number of fruits per plant (6.47), weight of fruit (85.47 g $plant^{-1}$) and fruit yield of okra (4.56 t/ha) were recorded in 75% RDN through neem coated urea + 25% RDN through vermicompost (T_5). Thus, among different integrated nitrogen management treatments, the combined application of 75% RDN through neem coated urea + 25% RDN through vermicompost significantly influenced the growth and yield parameters of okra in open field condition as well as in teak based silvi-horticulture system.

References

Kumar A and Choudhary AK 2014. Scientific cultivation of okra. **In:** *Advances in Vegetable Production*, N. Rai and D.S. Yadav (eds.). Scientific publication, New Delhi, India. Pp. 25-30.

Miller H 2007. Poultry litter induces tillering in rice. *Journal of Sustainable Agriculture* **31**: 1-12.

2.41/T_2-200

Raw Material Augmentation vis a vis Farmer's livlihood through Clonal Plantations: Status and Challenges

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Keywords: Paper industry, MDF/ply board, social forestry, agroforestry, clonal plantation

1. Intorduction

Undoubtly, there is a major mismatch in demand and supply of quality wood available in the market particulary in North India for Paper Industeies. The situation has come now at this stage where industeries (particularly for MDF/Plyboard and Paper Industeries) have a big challenges to meet their increasing demand for wood. The demand of wood remained under control during pandemic i.e. Covid-19 as all Paper industeries were facing a major set back due to very low demand of pulp and Paper in Indian market or in other words it was a major loss of Indian economy. Post covid i.e. in the beginning of 2022 onwards, almost all paper mills did a huge business through record sale of their prodcuts i.e. Paper during the year after a major set back. It created a mjaor pressure on the market for quality wood. It is also true that in pandemic, farmers were in a great fear about their lives and livelihood which affected the regular plantations activties to a great extent.

Can not ignore that there is a acute shortage of quality wood in North India market particularly Yamuna Nagar (Asia's biggest wood market), Haryana and Hoshiarpur in Punjab. At present, only 40-45% wood is coming in both the market which is not sufficient as per the demand and further there is no sign of any improvement in the next 2-3 years. Availability is again a major challenges before all the Paper mills like Century, Naini, Star, Kuantum, Trident and Satia of North India to cop up their demand. It is also true that few mills have started procurement of wood from other states like Uttar Pradesh, Jharkhand, Chattisgarh, Odisha and Andhra areas which increased their prodcution cost to a good extent. Another is mismtach in prices as MDF and Ply boards are offering high rates to farmers and upward revision in prices have created an undue situation for the Paper Mills to secure their desired quantity. Now the shortage of raw material i.e.wood is not only limited to Paper industeries but it is same for other wood based industeries like MDF and Ply boards. To reduce this pressure Industry like Kunatum Paper Limited has planned and taking major initiatives to promote major plantations programme in and around the areas.

2. Methodology, outreach and results

Kuantum Papers has a good rapport in National and International market and has a long history of more than 30 years (since 1980). KPL is one of the leading integrated Pulp and Paper mills of North India and manfacturing a variety of papers e.g. Maplitho, Coloured Paper, Ledger, Cartridge, Parchment, Duplicating Paper and wood free speciality papers. Company use both agro and wood as raw material. In wood mainly focus from Eucalyptus, Bamboo, Poplar, Melia and other fibrous species. KPL is the leader in the cream wove paper in agro-based segment. The industry is also actively engaged in implementing and promoting agro forestry and social forestry programmes on large scale in different districts of North Punjab. Company started clonal plant prodcution in its Hi-tech clonal nursery with a capcity of 5 lacs which now has increased upto 10 lacs this year and it will be increased upto 20 lacs in 2023-24. Company has a clear vision to expand its prodcution capacity from 20 to 1 crore quality seedling of superior Clones of Eucalyptus in the next 3-5 years upto 2027-28 which will definitely increase the plantations area of around and finally will improve the availability of wood particulary in the radius of 200 km from the mills. Beside the above, Poplar nurseries under PPP (Public Private Partnership) will also be raised for the production of superior clones of Poplar. At present, Company is distributing quality seedlings of Eucalyptus and Poplar to farmers of the local areas and providing technical suppports to farmers communities for better out put in terms of better yield and also giving a good market by providing them a fair value of their crop. Till date, Company has covered more than 2000 farmers in its record. To create awareness and to motivate farmers, every month farmers meeting are being planned in various villages as per fixed calender. Plantation team brief all about the benefits of plantations, its maintenance for better outputs, market, by back system and plantation of other species. Under R&D programme, we have also taken field testing of other pulpwood species like Casuarina, Melia and Subabul are also being taken. Initial growth of the one year old Casuarian clone CJ-1 showed a better response in terms of survival percentage and height i.e. 4-5 mt. Apart from this, we are also multiplying, CJ-1 in our Clonal hi-tech nursery. To test the suitability of Casuarina clone, as an alternative plantation species on the farmer's land, around 5000 plants are being distributed to intersted farmers. Field data will be mainatained and monitored to check the suitability of Casuarina in the area, which further will be helpful to develop Social and Agorforestry in and around the area on major scale. Plantation on such scale will be a boon for the Paper industry where an alternative raw material will be made available to meet their requirement for wood and also will reduce the competition between Paper and MDF/Ply board industries and finally to will control the prices.

3.1/T_3-07

Genotypic Influence on Epicormic Shoot Production from Branch Cuttings and Pruned Trees and Rooting of *Tectona grandis* Linn. f.

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Keywords: Teak, rooting, shoot induction, genotype, vegetative propagation

1. Introduction

Use of juvenile shoots for plant production in hardwoods has an advantage over stem cuttings through an improved root system, rooting potential, and reduced lignification. In general, juvenile propagules in trees are produced by either coppicing or girdling (Thakur et al 2021). Production of juvenile shoots by forced epicormic bud bursting on stick branch cutting and pruned trees without losing the mother tree is an option. There is limited knowledge on the influence of genotypes on epicormic shoot production from branch cuttings and pruned trees and its rooting in *Tectona grandis.*

2. Material and methods

Branch cuttings (2-4 cm in diameter and 1.5 m in length) of 18 genotypes were collected from the middle to lower part of the crown, treated with carbendazim 2% (50% WP), planted in soil media and maintained in a mist chamber. Simultaneously, 2-year-old clones of the same genotypes were pruned up to 2 m from the ground and assessed for sprout production. For initiation of roots, epicormic sprouts were treated with IBA (3000 mg L^{-1}) and planted in vermiculite-filled root trainers and kept in a mist chamber.

3. Results and discussion

Budburst started from the 5^{th} and 7^{th} day of planting in the detached branch and pruned trees, respectively. The genotypes showed significant variation in the production of epicormic shoots (p=0.002). Among the branch cuttings, genotypes Aravallikkavu, Top slip-6, and Nellikutha-7 produced the maximum number of epicormic shoots, whereas Nedumkayam-1 produced one or no shoots.

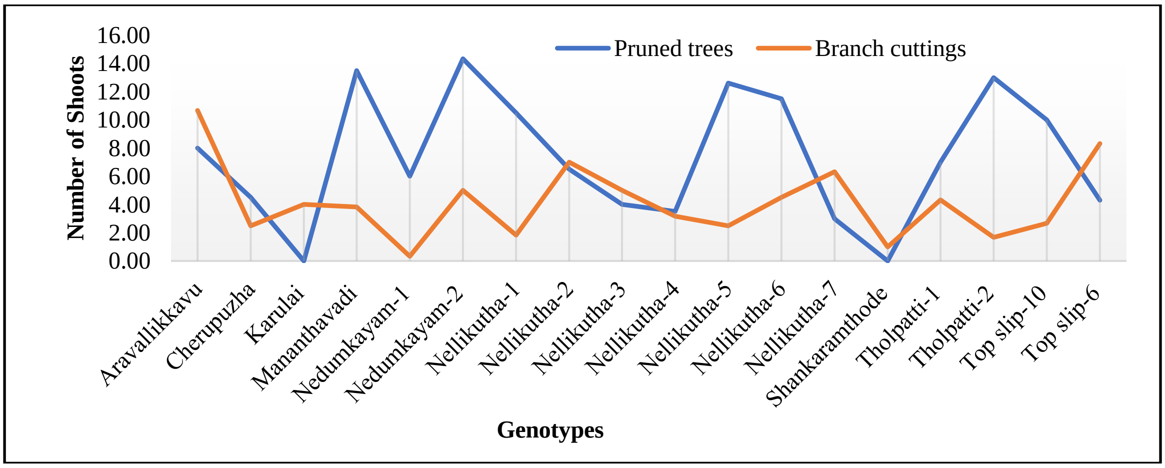

Fig. 1. Influence of genotypes on epicormic shoot production in Teak

Among pruned trees, Nedumkayam-2 produced the maximum sprouts, while Shankaramthode and Karuli had the least or no shoots.The range of the average shoot diameter among the various genotypes was 2.85 to 5.43 cm,while shoot length varied from 4.43 cm (Nellikutha-1) to 10.65 cm (Cherupuzha). The rooting percentage of the genotypes was examined on the 40^{th} day after planting and varied significantly (p=0.012). Nellikutha6 had the highest rooting percentage (57.11%), followed by Tholpatti 1 (47.89%) and Mananthavadi2 (39.11%).The study's findings indicate that plant genotype influences adventitious shoot and root production in *T. grandis*. It is suggested that this be considered during the selection for tree improvement.

Reference

Thakur NS, Hegde HT, Chauhan RS, Gunaga RP and Bhuva DC 2021. Root sucker technique for successful clonal multiplication of *Melia dubia* Cav. without sacrifice of mother tree. *Current Science* **121**(9): 1235.

3.2/T_3-12

Ecotype Diversity Assessment of Autumn Olive (*Elaeagnus umbellata* Thunb.) in Himachal Pradesh

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Keywords: Autumn olive, diversity, dominance, ecotype

1. Introduction

The wild species are flourishing at a vast range of habitats in Himalayas. Among the wild species, *Elaeagnus* is the largest shrub genus of Elaeagnaceae family. *Elaeagnus umbellata* Thunb. (Autumn olive) is a multipurpose actinorhizal shrub of the Western Himalayas, distinctly distributed at a range of about 1200 m to 2100 m, withstanding the eroded areas owing to renowned nitrogen fixing ability (Ahmad et al 2006).

2. Material and methods

The wild shrub was recorded at two locations from each altitudinal ranges *viz.*, <1200 m, 1200-1800 and >1800 m. At each location, in vicinity of the shrub the ecological status was evaluated, the diversity indices were calculated on the basis of data availability. The growth of *Elaeagnus,* in any environment was majorly influenced by soil parameters. Therefore, the effect of *Elaeagnus* on the soil parameters (pH, EC, soil N, P and K) was appraised.

3. Results and discussion

E. umbellata Thunb. has tendency to spread abundantly and establish itself in natural areas. The results depicted the associated species adjacent to *E. umbellata* were *Rosa moschata, Berberis lycium, Berberis aristata, Prinsepia utilis, Rubus leucodermis, Barleria cristata, Artimesia, Gallinsoga, Thallictrium foliolosum* and many others. Due to its invasive nature, it outcompetes the native species such as *Myrisine africana, Lantana camara, Coraria nepalensis, Zanthoxylum aratum, Bidens pilosa* and *Setaria glauca* in chirpine forest. In the kail forest *Sambuca nigra, Ruscus, Indigofera, Lonicera, Eunymus europaeus, Urena lobata, Viola* and *Liparis* were absent in its vicinity. The maximum dominance was depicted by *E. umbellata* Thunb. due to its high propensity for invasion and rapid growth (Attri et al 2017).

Table 1. Importance Value Index (IVI) of shrubs present in all the six population

Species	Dilman		Kujji		Kalaghat		Nauni		Dhar		Shari	
	EP	EA	EP	EA	EP	EA	EP	EA	EP	EA	EP	EA
Berberis aristata	-		-	-	-	-	-	-	102.6	72.4	27.5	44.9
Berberis lycium	38.7	40.8	43.6	-	70.1	46.0	65.4	84.1	-	-	-	-
Carissa spinarum	24.5	20.2	21.5	33.5	12.5	-	-	-	-	-	-	-
Cassia floribunda	-	15.3	17.9	28.1	-	-	-	-	-	-	-	-
Coriaria nepalensis	-	16.4	-	-	-	-	-	-	-	-	-	-
Caryopteris wallichiana	15.2	20.9	10.2		16.4	-	-	-	-	-	-	-
Daphne spp.	-	-	-	-	-	-	-	-	-	28.6	15.4	19.7
Elaeagnus umbellata	76.9	-	63.2	-	42.0	-	75.0	-	135.9	-	59.1	-
Euonymus europaeus	-	-	-	-	-	-	-	-	-	94.9	-	-
Hypericum oblongifolium	15.2	-	31.7	-	13.8	26.7	29.5	15.2	-	-	-	-
Indigofera spp.	-	-	-	-	-	-	-	-	-	35.2	24.1	-

Lantana camara	-	40.3	-	60.3	-	34.9	-	31.7	-	-	-	-
Lonicera angustifolia	-	-	-	-	-	-	-	-	-	88.4	19.1	29.3
Lonicera interrupta	-	-	-	-	-	-	-	-	-	-	8.6	-
Murraya koenigii	-	-	-	-	-	-	24.7	-	-	-	-	-
Myrsine africana	-	46.3	-	61.9	-	-	29.3	-	-	-	-	-
Peritoma arborea	-	-	-	-	-	-	9.9	-	-	-	-	-
Plectranthus rugosus	-	-	-	-	-	-		-	-	-	18.6	-
Prinsepia utilis	-	-	18.5	-	18.3	22.4	31.4	50.1	43.1	48.3	34.6	30.5
Pseudocaryopteris bicolor	-	-	-	-	27.4	15.9	6.0	-	-	-	-	-
Rhamnus spp.	-	-	-	-	20.6	10.7	-	-	-	-	-	-
Rosa moschata	55.2	44.3	24.5	43.3	45.2	50.3	35.9	58.7	23.3	28.4	26.6	39.4
Rosa mulliganii	-	-	7.8	-	-	-		-	75.0	33.3	-	-
Rubus leucodermis	-	-	-	-	-	-	-	-	62.2	-	-	-
Rubus ellipticus	47.9	33.0	43.6	53.2	33.5	53.4	32.2	33.6	-	72.7	29.3	41.4
Rubus niveus	-	-	-	-	-	-	-	-	52.1	-	-	-
Ruscus aculeatus	-	-	-	-	-	-	-	-	30.9	-	-	30.7
Sambuca nigra	-	-	-	-	-	-	-	-	-	38.1	-	15.4
Sarcococca saligna	-	-	-	-	-	-	-	-	-	-	16.3	-
Symphoricarpos orbiculatus	-	-	-	-	-	-	-	-	-	79.3	-	-
Viburnum prunifolium	-	-	-	-	-	-	-	-	13.3	-	20.8	38.3
Zanthoxylum armatum	26.4	22.3	17.7	19.7	-	-	-	26.6	-	-	-	-

References

Ahmad S D, Sabir S M and Zubair M 2006. Ecotypes Diversity in Autumn olive (*Elaeagnus umbellata* Thunb.): a single plant with multiple micronutrient genes. *Chemistry and Ecology* **22**(1): 509-21.

Attri V, Sharma D P and Dhiman R 2017. Floristic diversity and natural regeneration status of Chir pine (*Pinus roxburghii* Sargent) forest: a case study of Rajgarh forest division of Himachal Pradesh. *Bulletin of Environment Pharmacology and Life Sciences* **6**(1):1-6.

3.3/T3-15

Variation Studies in Fruit and Seed Characteristics of *Diospyros montana* (Roxb.) in Himachal Pradesh

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Keywords: *Diospyros Montana*, Ebenaceae, NTFPs, fruit

1. Introduction

India is blessed with all types of vegetation ranging from tropical to subtropical, temperate to subalpine and alpine because of diversified climatic and physiographic factors their identification and classification are often unsatisfactory, leading to considerable confusion when plants or their products are traded. Among all, genus *Diospyros* is one of the potential NTFPs. *Diospyros* is largest genus of family Ebenaceae, around 700 species of deciduous and evergreen trees and shrubs (Akagi et al 2014). Out of which *Diospyros montana,* commonly known as Bombay ebony found in some parts of Solan, Sirmour and Una district of Himachal Pradesh, India. *D. montana* is a small deciduous tree up to 20 m high with spiny trunk and branches. It is a dioecioustree species. It is the one of the most important medicinal plant.

2. Material and methods

The tree samples were collected from two locations from altitudinal ranging from 1200-1900 ft. Total 19 mother trees from Nalagarh and Baddi area of district Solan of Himachal Pradesh were selected. Fruits were collected from each mother tree. The 19 mother trees were assessed for fruit and seed parameters.

3. Results and discussion

Variation in fruit and seed were studied by collecting fruits. There was large variationobserved in fruit and seed attributes. The maximum fruit weight, fruit length and fruit width was recorded for M_5 and M_7. This study revealed that fruit size could form a selection criteria for tree improvement in *D. montana.* Number of seeds recorded maximum in M_1, whereas seed weight (100 seeds) was observed maximum in M_3. The size of seed varied due to external and internal environmental conditions (Roy et al 2004).

Table 1. Variation for fruit and seed characters in *D. montana*

Mother trees	Fruit length (cm)	Fruit width (cm)	Seed length (cm)	Seed width (cm)	Fruit weight (g)	Number of seeds per fruit	100 seed weight (g)
M_1	2.98	3.24	1.55	0.79	14.47	5.63	155.34
M_2	2.92	3.24	1.43	0.91	11.78	3.33	123.18
M_3	2.9	3.22	1.41	0.84	13.33	4.43	182.97
M_4	2.96	3.35	1.48	0.86	13.6	3.83	174.83
M_5	3.09	3.46	1.41	0.79	14.99	4.9	141.94
M_6	3.06	3.4	1.42	0.68	12.61	4.33	128.97
M_7	3.08	3.42	1.39	0.8	14.47	4.9	151.60
M_8	3.01	3.09	1.4	0.89	13.38	3.4	145.47
M_9	2.85	2.94	1.41	0.83	10.67	4.73	156.37
M_{10}	2.9	3.04	1.42	0.79	10.49	3.93	127.70
M_{11}	2.95	3.23	1.32	0.73	11.66	4.77	140.40
M_{12}	2.67	3	1.31	0.77	9.99	4.7	106.70
M_{13}	2.78	3.07	1.32	0.78	10.2	4.37	106.37

M_{14}	3.1	3.09	4.13	0.79	11.16	4.93	161.63
M_{15}	2.85	3.1	1.27	0.69	10.36	3.97	102.57
M_{16}	3.04	3.16	1.56	0.89	11.44	4.57	152.23
M_{17}	2.85	2.94	1.22	0.63	8.96	4.23	126.77
M_{18}	2.89	3	1.56	0.8	9.39	5.23	168.90
M_{19}	2.87	3	1.31	0.68	7.28	3.33	135.33
$CD_{0.05}$	0.08	0.10	0.08	0.04	0.93	0.64	22.53

References

Akagi T, Henry I M, Tao R and Comai L 2014. A Y-chromosome encoded small RNA acts as a sex determinant in persimmons, Science. *Plant genetics* **346**(6209):646–50.

Roy SM, Thapliyal R C and Phartyal SS 2004. Seed source variation in cone, seed and seedling characteristic across the natural distribution of Himalayan low level Pine (*Pinus roxburghii*) *Silvae Gentica* **53(**1-6**)**:116-129.

3.4/T$_3$-16

Geographical and Genetic Variability in *Pyracantha crenulata* (D. Don) M. Roem Genotypes

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Keyword: *Pyracantha crenulata,* Genetic Variability, molecular characterization, germplasm

1. Introduction

Evergreen and perennial shrub *Pyracantha crenulata* (Rosaceae) is a wild plant species of the mid-Himalayas (900-2500 m amsl). This multipurpose shrub is a good source of soil binder, helps in soil conservation and controls desertification, and has high medicinal value (Singh et al 2018). Genetic studies haven't been conducted on this species. DNA markers are used for its molecular characterization for the first time.

2. Material and methods

Total genomic DNA was extracted from the leaves of 80 genotypes using the modified method of Doyle and Doyle (1987). A total of 16 ISSR primers were used to screen all genotypes and reveal genetic diversity. PCR was performed to amplify each genotype. The amplified PCR fragments were analysed using a binary data matrix. The similarity coefficient matrix and UPGMA dendrogram were generated for estimating genetic diversity among genotypes. PCoA analysis was performed for geographic distribution.

3. Results and discussion

305 alleles were generated using 13 polymorphic ISSRs. Marker analysis showed that genotypes maintained high genetic diversity (h = 0.317; I = 0.482). Clustering analysis showed a Jaccard coefficient ranging from 0.515 to 0.934, indicating moderate genetic variability among genotypes. Genotypes 32 and 56 were the most divergent genotypes (0.515), revealing potential heterogeneity for improvement in breeding programs. UPGMA clustering pattern represented genotypes according to their geographical distribution and PCoA supported largely to the results. Results were also confirmed by Mantel test, which yielded the highest cophenetic correlation coefficient (r = 0.768) between dendrogram clusters and similarity matrices. This molecular approach provided adequate information on genetic and geographical variability in *P. crenulata* which contributes in evolutionary dynamics, efficient use of germplasm resources, and plant conservation.

References

Doyle JJ and Doyle JL 1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochemical bulletin* **19**:11-15.

Singh R, Negi PS and Dwivedi SK 2018. Indian Hawthorn (*Pyracantha crenulata*), pp 135-149. **In:** Singh B, Peter K, (eds.). *New Age Herbals.* Springer Nature Singapore Pvt. Ltd., Singapore.

3.5/T$_3$-18

Genetic Diversity of *Populus deltoides* Clones on the Basis of Morphological, Wood Traits and Molecular Markers

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Keyword: *Populus deltoides,* clones, genetic diversity, wood traits, molecular markers

1. Introduction

The *Populus deltoides* clones are being used in short rotation forestry in tropical and subtropical regions of the world. There is a collection of open pollinated *Populus deltoides* clones procured from different countries namely USA, Australia and parts of India and maintained in the germplasm in College of Forestry nursery, Dr. Y S Parmar UHF, Nauni, Solan (HP) India. There was need to study genetic diversity among these clones in order to use them in hybrid development.

2. Material and methods

Ninety-five clones were raised with stem cuttings in the nursery in RBD with three replications at 50x50 cm spacing and were evaluated for morphological characters in field as well as wood and molecular studies in laboratory. Phenotypic traits were measured at 2 years after planting including growth (plant height, basal diameter, inter nodal length, number of branches and branch nature), wood (wood Specific gravity, fibre length, moisture content of wood, bark thickness, bark percentage, wood percentage, wood bark ratio, lignin content and holocellulose content) traits and clustering was done with SPSS software. The DNA was extracted from fresh leaves and amplified with SSR (Simple Sequence Repeats) markers. The molecular data was analyzed for genetic diversity with NTSYS software and population structure was implemented in the software STRUCTURE ver 2.2 (Pritchard et al 2000).

3. Results and discussion

Analysis of variance revealed significant difference among all morphological traits. On the basis of clustering of morphological and wood traits, ninety five clones were distributed into five distinct clusters suggesting the presence of different sources of relationships amongst the clones. In genetic diversity studies using SSR markers, out of hundred markers, ninety three gave results and dendrogram generated from ninety three SSR markers divided whole population of ninety five clones into two major clusters. Results of population structure analysis also confirmed the genetic diversity results by partitioning the *P. deltoides* population into two sub-populations. Therefore, results from genetic diversity analysis as well as STRUCUTRE analysis showed that the clustering pattern of the genotypes in STRUCUTRE analysis were almost similar to the splitting in the UPGMA tree.

Reference

Pritchard JK, Stephens M. and Donnelly P. 2000. Inference of population structure using multilocus genotype data. *Genetics* **155**:945–959.

3.6/T_3-19

Pollination Biology in *Lawsonia inermis:* An Evidences from Hot Semi-arid Region of Rajasthan, India

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Keyword: *Lawsonia inermis,* pollination, dye, fruit set, henna

1. Introduction

Lawsonia inermis L. belongs to the family Lythraceae commonly called as Henna or Mehndi has been commercially cultivated promising dye yielding cash crop which is mainly used for dyeing hair, palm and feet since ancient times. Pollination is an essential step in ensuring seed production and it is a critical stage in the sexual reproduction of plants. According to Miczak (2001) and Roy and Jindal (2009), henna is a self-pollinating species. However, studies on mode of pollination of henna are still unclear and very limited. This study aimed to ascertain the mode of pollination in henna.

2. Materials and methods

The effect of pollination control on fruit setting in henna was studied in henna experimental field, at ICAR-Central Arid Zone Research Institute (CAZRI), Regional Research Station (Pali-Marwar, Rajasthan) in hot semi-arid region of India during 2017-18 to 2020-21. Region expriemces annual average rainfall of 460 mm with annual maximum mean temperature of 42°C and minimum 7°C. Two types of pollination systems *viz*., natural open pollination and pollination in controlled condition were studied. Total of 10 inflorescences borne on ten different 20-year old henna plants were selected and covered with muslin cloth bags and butter paper for controlled pollination. Simultaneously, 10 inflorescences of same plants were kept uncovered for open pollination.

3. Results and discussion

Out of three modes of pollination studied, maximum fruit set (60.84%) was observed in natural open pollinated condition while minimum fruit set (11.78%) recorded in controlled pollination covered with butter paper followed by controlled pollination covered with muslin cloth (10.10%). The highest fruit flower ratio also registered in natural open pollinated condition (0.608), whereas lowest were recorded in controlled pollination covered with muslin cloth (0.117) followed by controlled pollination covered with butter paper (0.101). Besides, the common flower visitors also observed which may favour the cross pollination in henna flowers. This study confirms that henna is both self and cross pollinated species.

References

Miczak MA 2001. Henna's secret history- The history, mystery and folklore of henna. Publishers Writers club press, San Jose, Newyork Lincoln, Shanhai. p. 326.

Roy PK and Jindal SK 2009. Variability and stability of genotypic performance in Henna (*Lawsonia inermis* L.) under semi-arid conditions of Rajasthan. *Indian Journal of Plant Breeding* **69**(2): 140-144.

3.7/T_3-22

Evaluation of Morpho-Physiological Characters of Half-sib Progenies of Selected *Melia dubia* Cav. Populations

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Keyword: *Melia dubia*, progenies, morpho-physiological variability, genetic gain

1. Introduction

Melia dubia Cav. commonly known as Malabar Neem, belongs to the prime family Meliaceae is a fairly large, deciduous tree with multivarious use (Saravanan et al 2013; Thakur et al 2021). However, studies on variations in physiological characteristics and their relationship with growth traits are meagre. Therefore, the current study evaluates the half-sib progeny of the selected *M. dubia* accessions collected from different regions of Kerala.

2. Materials and methods

A total of 25 candidates plus trees of *M. dubia* were selected through exploratory surveys from natural habitats of different regions of Kerala. Fifteen *M. dubia* seedlings from each genotype were grown for up to five months to measure various seedling growth parameters and physiological parameters. Variances (phenotypic, genotypic, and environmental) and their coefficients of variations were estimated as per Burton (1952). Whereas broad sense heritability, genetic advance (GA), and genetic gain (GG) were computed as per the methodology described by Johnson et al (1955).

Result and discussion

Substantial difference was observed among the overall genotypes for all the morphological traits, and accession no. FCV-MD-03 and FCV-MD-04 showed the best performance (Table 1). In morphological traits, maximum genotypic (24.53), phenotypic (22.44), and environmental variability (9.91) was recorded in biovolume of the species. Similarly, high heritability for biovolume (0.84), genetic advance (792.58), and genetic gain (42.29) indicated that selection for these traits would be effective for the tree improvement program.

Table 1. Genetic parameters of morpho-physiological characters in *M. dubia*

	H^2	PCV	GCV	ECV	Genetic advance	Genetic Gain
Morphological parameters						
Height	0.91	12.62	12.01	3.87	36.53	23.55
Collar diameter	0.53	13.98	10.18	9.58	0.18	15.26
No of leaves	0.65	13.45	10.88	7.9	4.24	18.15
AGR	0.83	18.28	16.65	7.54	0.72	31.25
Biovolume	0.84	24.53	22.44	9.91	792.58	42.29
Physiological parameters						
Chlorophyll	0.82	8.71	7.87	3.73	6.46	14.66
Photosynthetic	0.72	41.74	35.53	21.90	1.23	62.32
Stomatal conductance	0.80	64.28	57.50	28.75	0.12	105.94
Transpiration	0.81	51.87	46.60	22.77	1.45	86.26
Leaf temperature	0.92	5.77	5.53	1.65	3.65	10.91

Among the physiological traits, higher phenotypic (64.28), genotypic (57.5), and environmental variability were recorded in stomatal conductance. High heritability (0.91) and maximum genetic advance (105.94) were measured in leaf temperature, whereas maximum genetic gain (6.46) was found in chlorophyll content. Substantial growth variation among the progenies indicates the genetic ability of individual progenies. The existing genotypic variation can be exploited for further improvement of the species. These results show considerable scope for developing a superior genotype and its germplasm resource management.

References

Saravanan V, Parthiban KT, Kumar P and Marimuthu P 2013. wood characterization studies on *Melia dubia* Cav. for pulp and paper industry at different age gradation. *Research Journal of Recent Science* **2**: 183-188.

Thakur NS, Hegde HT, Chauhan RS, Gunaga RP and Bhuva DC 2021. Root sucker technique for successful clonal multiplication of *Melia dubia* Cav. without sacrifice of mother tree. *Current Science* **121**(9): 1235-1237.

3.8/T_3-23

Stability Analysis of Newly Developed Willow Clones (*Salix* spp.) for Growth Traits

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Keyword: Willow Clones, stability analysis, volume index, growth traits

1. Introduction

The willows are short-rotation tree species having multifarious uses. The superior willow clones were introduced from foreign countries *i.e.* UK, New Zealand *etc*. at Dr. Y S Parmar, UHF, Nauni, Solan HP, India. The hybrids were developed by involving the superior willow clones. These were screened in the nursery (Sharma et al 2017) and the selected clones were further raised at three sites in Himachal Pradesh, India, for the selection of stable clones on the basis of growth parameters.

2. Material and methods

The two years old willow clones were measured for plant height and diameter at breast height at Lana Palar (Sirmour), Thunag (Mandi) & Nauni (Solan) and volume index was calculated by multiplying the square of diameter with height asits relative index. The data were analysed by using Eberhart and Russel, Additive Main Effect and Multiplicative Interaction (AMMI) and GGE models for genotype x environment and stability parameters.

3. Results and discussion

With the regression model, clones UHFS068, UHFS112 and UHFS062 were found stable for plant height, diameter at breast height and volume index, respectively. For rich and poor environments, clones UHFS114 and UHFS062 were more suitable, respectively. The results from AMMI showed that clone J799 was better performing for all the studied traits whereas, clone J795 that was having similar performance in all three environments. Using the GGE model, Environment 2 *i.e.,* Thunag was found most discriminating and representative among all the three environments. However, the mean vs. stability from GGE and MTSI revealed that the most stable and better-performing clones were J799 and Kashmiri. The clone J799 was previously found stable for volume index (Singh et al. 2014). Therefore, this study identified the stable clones that can be recommended for the commercial plantation of willow in different geographical regions of Himachal Pradesh.

References

Singh NB, Sharma JP, Chaudhary P and Gupta RK 2014. Genotype x Environment interaction and growth stability of exotic tree willow (*Salix* Spp) clones. *Indian Journal of Genetics and Plant Breeding* **74**(2): 222-228.

Sharma JP, Thakur S, Singh NB and Thakur Sapna. 2017. Performance of willow (*Salix* species) families at close spacing. *Indian Journal of Ecology* **44**(6):

3.9/T_3-24

Identification of Superior Clone of *Dendrocalamus stocksii* from the Germplasm Bank at DBSKKV, Dapoli for Mass Multiplication

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Keyword: *Dendrocalamus stocksii*, clone, germplasm, strips, scaffolding

1. Introduction

Dendrocalamus stocksii is a one of the important crop belonging to the family Poaceae and sub family Bambusoideae. It is naturally distributed in the Central Western Ghats of Maharashtra, Goa, Karnataka and Kerala. It is widely used as a building material for scaffolding, housing, furniture, fences, stakes, handicrafts, decorative arts and other farming equipment, while the young shoots are edible.

2. Materials and Methods

College of Forestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri Maharashtra, India, has 63 accessions of *D. stocksii* collected from all over Western Ghats and planted at Biodiversity Park as a germplasm in 2014. Visually superior clumps were identified and marked. Various physiological, morphological, and genetical parameters were evaluated for each accession. The selection of phenotypically superior clumps was based on comparative approach and grading for desirable characteristics.

3. Results and discussion

The basal diameter of 10 selected superior CPC culms ranged from 48-55 mm. The average number of strips estimated per culm ranges from 141.3 – 172 strips. The different parameters of *D. stocksii* were observed for scaffolding purpose such as the average diameter (40.32 to 50.7 mm), height of culm (6.5 to 12 m), commercial height (3.43 to 7.8 m), number of nodes (28 to 36), tapering, straightness of culms, culm wall thickness (16 to 22.5 mm), fresh weight (6.04 to 8.35 kg) and dry weight (5.04 to 6.73 kg), and strength of culm (14.85 to 18.44 Gpa). The 10 selected CPC series of *D. stocksii* showed best suitability for strips and scaffolding purpose.

References

Rane AD 2015. Morphological, physiological and genetic variations in *Dendrocalamus stocksii* (Munro) along the Central Western Ghats. Forest Research Institute University, Dehra Dun, Ph.D. Thesis

Raut SS 2010. Identification of Candidate Plus Trees and seed source variation in *Pongamia pinnata* (L) pierre. College of Forestry, Dapoli, M.Sc. Thesis

3.10/T_3-28

Provenance Variation in Fruit and Seed Morphometric Characteristics of *Dysoxylum binectariferum* Across its Distribution in India

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Keywords: *Dysoxylum binectariferum*, seed morphometric traits, provenance variation, superior tree.

1. Introduction

Dysoxylum binectariferum is a medicinally important species found in tropical and subtropical climates. Seed collected from same geographical region vary in their morphological characteristics, which intern reflect the genetic control of formation of seed. *D. binectariferum* has vast diversity between trees as well as among provenances (Gunaga et al 2015). Therefore, study was undertaken to know the intra-species variation in fruit and seed morphological traits of *D. binectariferum.*

2. Material and methods

Seeds were collected from 7 populations from 4 states *viz*., 4 populations (Jog, Kargal, Benagaov and Kathagal) from Karnataka, one population (Lonavala) from Maharashtra, one population (Manas) from Assam and one population (Phasighat) from Arunanchal Pradesh. Matured 75 fruits from 5 superior trees from each source were collected during January from Western Ghat source and March from North-East source. Further, fruit and seed parameters like length, width and weight were recorded.

Table 1. Effect of seed source and tree variation on fruit parameters of *Dysoxylum binectariferum*

Source	Trees	Fruit weight (g)	Fruit length (mm)	Fruit diameter (mm)	Seed weight (gm)	Seed length (mm)	Seed diameter (mm)
		1	2	3	4	5	6
Joga	JT1	95.20^{a}	56.68^{a}	57.10^{a}	9.68^{a}	33.48^{a}	22.28^{a}
	JT2	51.44^{d}	39.82^{c}	51.45^{c}	7.51^{d}	33.04^{a}	20.17^{b}
	JT3	51.57^{d}	48.24^{b}	54.39^{b}	8.67^{b}	30.54^{c}	20.81^{b}
	JT4	86.66^{b}	55.62^{a}	57.77^{a}	8.13^{c}	31.89^{b}	20.45^{b}
	JT5	73.04^{c}	47.43^{b}	51.52^{c}	8.40^{b}	31.46^{bc}	20.82^{b}
	Mean	71.58^{a}	49.56^{a}	54.45^{a}	8.48^{a}	32.08^{a}	20.91^{a}
Kargal	KaT1	51.92^{a}	45.78^{a}	46.19^{c}	6.96^{b}	28.22^{a}	19.47^{ab}
	Ka T2	52.38^{a}	42.01^{b}	56.62^{a}	7.07^{b}	26.77^{b}	19.70^{ab}
	Ka T3	45.38^{a}	39.22^{c}	45.75^{c}	6.18^{c}	23.99^{c}	18.87^{b}
	Ka T4	57.47^{a}	41.94^{b}	55.22^{a}	7.59^{a}	27.31^{ab}	20.34^{a}
	Ka T5	53.07^{a}	40.02^{c}	49.51^{b}	6.51^{c}	27.35^{ab}	19.60^{ab}
	Mean	52.05^{b}	41.79^{c}	50.66^{b}	6.86^{c}	26.73^{c}	19.60^{b}
Kathagal	KtT1	56.81^{a}	45.28^{b}	48.15^{b}	7.19^{a}	28.64^{a}	20.10^{bc}
	Kt T2	38.86^{c}	40.89^{d}	49.70^{b}	7.24^{a}	26.64^{b}	20.63^{b}
	Kt T3	61.53^{a}	42.43^{c}	54.05^{a}	6.49^{b}	24.38^{d}	26.57^{a}
	Kt T4	61.52^{a}	47.06^{a}	49.60^{b}	6.62^{b}	25.40^{c}	19.64^{c}
	Kt T5	50.96^{b}	40.29^{e}	48.18^{b}	4.70^{c}	24.08^{d}	17.03^{d}
	Mean	53.94^{b}	43.19^{c}	49.94^{b}	6.45^{c}	25.83^{c}	20.79^{a}
Benagav	BT1	31.88^{c}	35.96^{e}	41.84^{d}	3.69^{c}	23.24^{c}	15.91^{c}
	BT2	37.68^{bc}	38.85^{c}	49.42^{a}	7.20^{b}	26.77^{ab}	19.45^{a}
	BT3	53.97^{a}	43.66^{a}	46.85^{b}	3.88^{c}	25.84^{b}	16.25^{c}
	BT4	38.98^{b}	37.35^{d}	44.14^{c}	3.91^{c}	25.03^{b}	15.78^{c}
	BT5	55.01^{a}	40.40^{b}	49.73^{a}	8.11^{a}	27.54^{a}	20.21^{a}
	Mean	43.51^{c}	39.24^{d}	46.40^{c}	5.36^{d}	25.68^{c}	17.52^{c}

Lonavala	LT1	44.89^{a}	39.52^{a}	42.23^{b}	3.65^{b}	25.18^{c}	15.65^{b}
	LT2	6.94^{c}	27.58^{c}	21.84^{d}	2.19^{d}	27.07^{a}	13.25^{c}
	LT3	43.37^{a}	38.90^{a}	42.18^{b}	4.46^{a}	26.18^{b}	17.00^{a}
	LT4	46.07^{a}	39.52^{a}	43.51^{a}	3.15^{c}	22.12^{d}	14.93^{b}
	LT5	18.49^{b}	32.11^{b}	30.38^{c}	2.01^{d}	19.73^{e}	12.46^{c}
	Mean	31.95^{d}	35.03^{e}	36.03^{d}	3.09^{e}	24.06^{d}	14.66^{d}
Manas	MT1	79.51^{b}	51.81^{a}	42.37^{d}	8.15^{b}	25.49^{c}	20.64^{b}
	MT2	68.01^{c}	41.59^{d}	58.13^{a}	9.03^{a}	31.79^{a}	21.54^{a}
	MT3	93.04^{a}	44.27^{c}	51.57^{c}	7.67^{c}	28.92^{b}	19.95^{b}
	MT4	42.80^{d}	50.04^{b}	50.09^{c}	9.17^{a}	29.15^{b}	20.42^{b}
	MT5	96.13^{a}	49.55^{b}	56.89^{b}	6.39^{e}	31.68^{a}	21.88^{a}
	Mean	75.90^{a}	47.45^{b}	51.81^{b}	8.08^{ab}	29.41^{b}	20.89^{a}
Phasighat	PT1	43.02^{d}	52.27^{a}	48.17^{c}	7.46^{b}	32.37^{a}	18.59^{b}
	PT2	92.37^{a}	46.62^{c}	49.09^{c}	8.97^{a}	27.32^{c}	19.24^{b}
	PT3	75.28^{b}	53.56^{a}	53.73^{b}	6.18^{c}	27.51^{c}	20.44^{a}
	PT4	64.45^{c}	39.82^{d}	42.36^{d}	7.83^{b}	28.74^{b}	19.67^{ab}
	PT5	89.14^{a}	47.29^{c}	56.84^{a}	8.89^{a}	28.58^{b}	19.98^{ab}
	Mean	72.85^{a}	47.91^{b}	50.04^{b}	7.87^{b}	28.90^{b}	19.58^{b}

Parameters	1		2		3	
	SE(m)±	CD@5%	SE(m)±	CD@5%	SE(m)±	CD@5%
Source	2.60	7.34	0.55	1.57	0.96	1.91
Trees	2.19	6.20	0.47	1.32	0.81	1.61
Source x Trees	5.81	16.41	1.24	3.50	2.14	4.27
Parameters	4		5		6	
	SE(m)±	CD@5%	SE(m)±	CD@5%	SE(m)±	CD@5%
Source	0.20	0.56	0.42	1.18	0.37	1.05
Trees	0.17	0.47	0.35	1.00	0.31	0.89
Source x Trees	0.44	1.24	0.94	2.64	0.83	2.35

3. Results and discussion

Significant variations were recorded for fruit and seed traits across population as well as between trees. Among population, the fruit and seed traits, namely fruit weight (71.58 g), fruit length (49.56 mm), fruit diameter (54.45 mm) seed weight (8.48g), seed length (32.08mm) and seed diameter (20.91mm) from Jog were found to be superior over the other followed by Manas and Phasighat, the second-best sources, whereas least was observed in Lonavala population for all fruit & seed parameters. Among superior trees, highest fruit weight (95.20g), fruit length (56.68mm) recorded for JT1, highest fruit diameter (57.77mm) for JT4, and least was recorded for LT2 tree in all fruit parameters. There was significant variation among thirty-five superior trees from seven provenances for all seed traits, highest seed weight (9.68g), seed length (33.48mm), and seed diameter (22.28mm) recorded for JT1 and least for LT2 (Table 1).

Reference

Gunaga RP, Manjunath AV, Gunaga SV and Vasudeva R 2015. Tree to tree variation in seed traits and germination in *Dysoxylum binectariferum* Hook.F. *Indian Forester* **141**(5): 578-580.

3.11/T3-29

Prepotency in Half-sib Progenies of *Grewia optiva* for Morphometric and Fodder Traits

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Keyword: ***Grewia optiva***, *progeny, fodder, variability*

1. Introduction

Grewia optiva Drummond commonly known as 'Beul' and very popular agroforestry tree which is grown in low and mid-hills regions in the western and central Himalayas on account of its utility as fodder, fuel and fiber. With the increase in demand for fodder, there is a need to develop clones of genetically superior trees. Therefore, evaluating locally adopted beul families for commercial cultivation is a priority area of research in improving the fodder quality.

2. Material and methods

A seedling seed orchard of *G. optiva* was established in July 2000, consisting of 60 families each under three replications at a spacing of 2 x 2 m. These different families have been sourced from various districts of Himachal Pradesh. For the present study, only 40 families were selected and evaluated for various morphometric and fodder quality parameters.

3. Results and discussion

The analysis of variance indicated highly significant differences among the families for all the morphometric traits and fodder quality traits studied, which revealed the existence of a good deal of variability in the seedling seed orchard of *G. optiva* (Sankhyan, et al 2016)

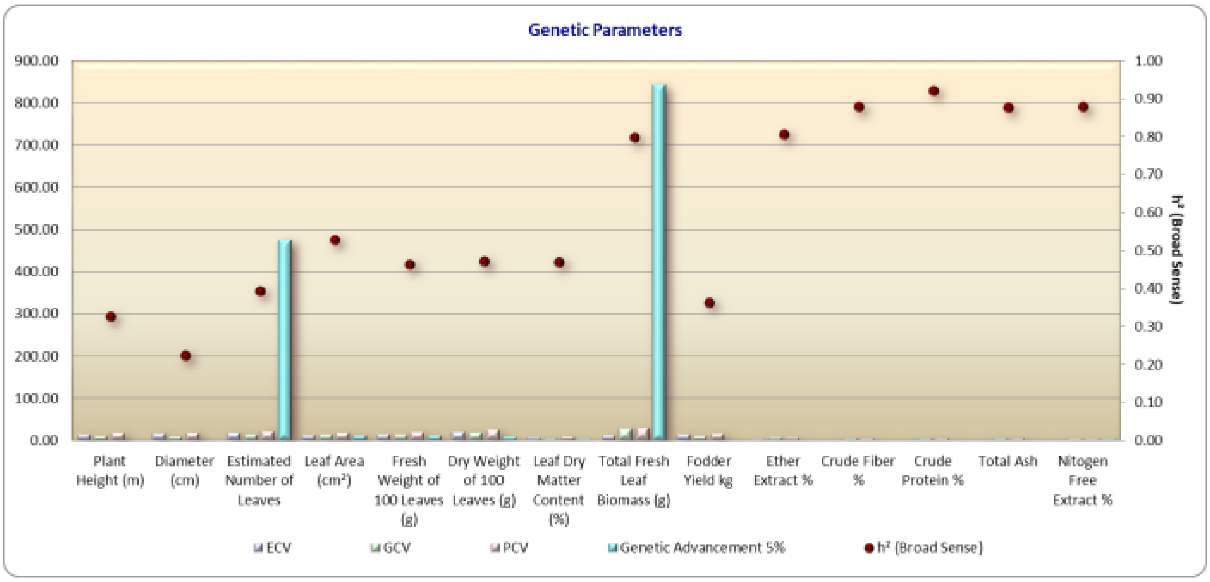

Fig 1: Estimates of variation and genetic parameters of different characters in *Grewia optiva*

Reference

Sankhyan HP and Bhagta Shikha 2016. Fodder quality analysis of open pollinated seedling seed orchard of *Grewia optiva* Drummond. *The Bioscan* **11**(2):709-713

3.12/T_3-32

Seed and Pod Trait Variations in *Bauhinia vahlii* Wight & Arn in Lower Himalayan Regions of Himachal Pradesh

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Keyword: *Bauhinia vahlii*, seed, pod,

1. Introduction

Bauhinia vahlii Wight & Arn. rise upto 15-30 m depending upon the size of the supporting trees in the forest. Its various parts have medicinal uses such as leaves are used as demulcent, edible seed as tonic, bark for extracting tannins and leaves are even used as fodder and commercially used as donas and pattals.

2. Material and methods

A survey was conducted and total of 10 seed sources were identified and five best co-dominant trees from each seed source were selected for fruit (pod) collection. Seeds were collected and seed parameter variation was studied for following characters: pod length, pod width, seed weight and seed colour. Seeds were extracted from the pods after measuring pod dimensions. 100 seed weight and respective colour of those seeds were noted further.

3. Results and discussion

Results for fresh seed weight showed significant variation among seed sources with maximum mean value of 136.9 g found in Bhojnagar seed source which shows the seed potential to germinate in other areas as well. Results computed in Table 4 revealed that Nurpur seed source had maximum pod length of 23.3 cm whereas Dharbanar seed source showed the maximum pod breadth of 5.88 cm. The best performing individuals with outstanding seed quality may be further examined for higher potential. The average weight of the seed varied from 113.4 to 136.9 g, pod length varied from 17.6 to 23.3 cm, pod breadth ranges from 4.82 to 5.88 cm.

Reference

Singhdoha A, Dhillon RS and Bangarwa KS 2017. Assessment of genetic variation among different provenances of *Acacia nilotica* CPTs for seed traits. *Indian Journal of Ecology* **44**(4): 259-265.

3.13/T_3-45

Evaluation of Half Sib Progeny of *Grewia optiva* Drummond under Nursery Conditions

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Keyword: *Grewia optiva*, Progeny, phenotypic variation, genetic advance

1. Introduction

Progeny testing is prerequisite to estimate the genetic worth of parents while screening the naturally available genetic base so as to isolate good genotypes rather than merely selecting good phenotypes and to achieve maximum gain per unit area. The aim of present study was to delineate genetically divergent best nutritive strains of *G. optiva* Drummond and generate promising breeding material.

2. Materials and methods

Seedling growth characteristics were evaluated for two years (*i.e.*, 2019–20 and 2020–21). The mean data of seedlings growth characteristics were subjected to ANOVA. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) analysis and genetic advancement and heritability value were estimated. Genotypic correlation coefficients and principal component analysis were calculated using OP-STAT (Sheoran *et al* 1998) and a cluster analysis was performed on PAST (Hammer *et al* 2001).

3. Results and discussion

Phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters under observation. A narrow difference existed between PCV and GCV in most characters, showing that they were comparatively stable to environmental pressure. GCV and PCV values were observed at their maximum for the number of branches (GCV: 20.97 % and PCV: 24.06 %) and branch angle (GCV: 22.30 % & 24.92 %). Heritability (H^2), Genetic Advance (GA) and Genetic advance as percent of mean (GAM) is given in Table 1. Genetic parameters permit identifying the action nature of involved genes as well as evaluating the efficiency of different selection methods and strategies. The highest heritability recorded for leaf area (91.22), highest genetic advance (64.20) for seedling height, and genetic advance as per cent of mean (41.12 %) observed for branch angle.

Table 1. Genetic estimates for growth characteristics of *Grewia optiva* progenies

Parameters	Range	GCV	PCV	H^2	GA	GAM
SH (cm)	30.99-87.44	18.674	19.908	87.985	64.204	36.084
R/S	0.4-0.61	8.907	12.185	53.426	0.191	13.411
BD (mm)	3.78-13.99	13.578	18.201	55.655	5.468	20.867
NB	5.61-13.67	20.978	24.066	75.983	10.965	37.669
IL (cm)	1.68-5.14	17.157	19.831	74.846	3.105	30.577
BA (˚)	15.54-66.66	22.308	24.927	80.094	49.486	41.127
LA (cm^2)	31.45-62.45	11.014	11.532	91.22	31.746	21.671
LL (cm)	5.3-8.99	12.925	13.832	87.319	5.438	24.88
LB (cm)	3.02-5.87	17.79	19.291	85.047	4.441	33.797
NL	45.13-137.21	12.202	15.581	61.328	50.509	19.684

Reference

Sheoran OP, Tonk DS, Kaushik LS, Hasija RC and Pannu RS 1998. Statistical Software Package for Agricultural Research Workers. Recent Advances in information theory, Statistics & Computer Applications by D.S. Hooda & R.C. Hasija Department of Mathematics Statistics, CCS HAU, Hisar (139-143)

Hammer Ø, Harper D A and Ryan P D 2001. PAST: Paleontological statistics software package for education and data analysis. *Palaeontologia Electronica* **4(1)**:1-9.

3.14/T3-56

Characterization of Population Variation for Germination and Seedling Traits of *Myrica esculenta* in Himachal Pradesh

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Keyword: *Myrica esculenta*, Kaphal, population variation, germination, germination value

1. Introduction

Kaphal (*M. esculenta*) is a minor and underutilized fruit species consumed by people since ancient times. It is a well-recognized medicinal plant in Ayurveda and Unani system of medicine. This species is generally propagated by seeds but physical dormancy caused by impermeable hard seed coat results in unreliable germination pattern. Now this tree is under threatened due to many factors. Therefore, the species need to be domesticated so that it can meet many diverse needs of the people. Before domestication study of provenances variation is important.

2. Material and methods

The present work was confined to 11 populations of *M. esculenta* distributed in Himachal Pradesh and five trees were selected from each population. Collected fruits were de-pulped and seeds were carefully air-dried before being immersed in hot water for 24 hours and then in GA_3 solution (1000 ppm) for another 24 hours. Treated seeds were sown in polybags with appropriate soil media with three replications. Seedling growth was recorded in the sixth month and the biomass parameters were estimated by destructive sampling at the end of the experiment (six month).

Table 1. Population variation for germination per cent, mean daily germination (MDG), peak value (PV) and seedling quality index in *M. esculenta*

Region	Population	Germination (%)	MDG	PV	SQ	DQI
Shimla	Shogi	31.60±0.65	0.53±0.01	0.58±0.01	4.85±0.52	0.20±0.03
	Taradevi	28.93±0.78	0.48±0.01	0.68±0.02	4.48±0.20	0.16±0.01
	Tutu	14.80±0.61	0.25±0.01	0.35±0.01	4.61±0.24	0.19±0.01
Sirmour	Bagpashog	29.87±0.77	0.50±0.01	0.66±0.02	4.57±0.21	0.15±0.01
	Chakala	16.93±0.47	0.28±0.01	0.33±0.02	5.32±0.30	0.16±0.01
	Dabara Baranji	14.53±0.36	0.24±0.01	0.31±0.01	4.96±0.25	0.25±0.03
	Rajgarh	12.53±0.60	0.21±0.01	0.21±0.01	4.15±0.28	0.16±0.02
	Serbharal	19.73±0.61	0.33±0.01	0.41±0.01	4.16±0.46	0.17±0.02
Solan	Bisha	5.73±0.33	0.10±0.01	0.18±0.01	3.99±0.28	0.17±0.01
	Jaunaji	24.00±0.92	0.40±0.02	0.56±0.01	4.27±0.28	0.22±0.03
	Shilly	15.73±0.67	0.26±0.01	0.30±0.01	3.98±0.22	0.17±0.01
$LSD_{0.05}$		1.15	0.02	0.003	0.794	0.045

AQ=Sturdiness Quotient; DQI=Dickson Quality Index

3. Results and discussion

Variations for nursery growth and biomass parameters were found significant. Shogi population had the highest germination percentage (31.60%) and mean daily germination (0.53), whereas peak value and germination value were found highest in Bagpashog (0.66) and Taradevi (0.33) populations, respectively. Bisha had the lowest value for all these parameters. No single population was found to be the best in all the traits. However, Dabara Baranji population showed the highest Dickson quality index (0.25). Wild populations exhibited radical difference for germination and seedling growth parameters. Populations from Sirmour region excelled all the other populations in terms of all the parameters.

Similar intraspecific variation for germination in pine species has been reported by Lopez-Upton et al (2005).

Reference

Lopez-Upton J, Donahue J and Plascencia-Escalante F 2005. Provenance variation in growth characters of four subtropical pine species planted in Mexico. *New Forest* **29**:1-13

3.15/T_3-85

Genetic Diversity among the Natural Population of Malabar Neem (*Melia dubia* Cav.) in South Gujarat

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Keyword: *Melia dubia*, Malabar neem, genetic diversity, molecular profiling, ISSR markers

1. Introduction

Melia dubia, a short rotational agroforestry tree species, has earned wide fame among farmers of India for its apparent monetary benefits. To gain first-hand knowledge about population structure and diversity, unexplored naturally occurring four populations of this species are being examined in India's northernmost Western Ghats region.

2. Material and methods

The present investigation was carried out at the College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India, from January-July 2021. Four populations of *M. dubia viz.* Kaprada (KP), Nanapondha (NP), Waghai (WG) and Sagai (SG*)* were selected from the natural growing regions of the hilly tract in South Gujarat. We used the Random amplified polymorphic DNA (RAPD) markers technique to reveal the genetic diversity among selected populations of *M. dubia*.

3. Results and discussion

Molecular profiling of four natural populations comprising 40 genotypes was done with RAPD markers. A total of 59 loci were amplified with ten deca-primers, of which 44 (74.58 %) loci were polymorphic, and 15 (25.42 %) were mono-morphic. In the current genetic diversity analysis, ranges of genetic diversity variables (PPL, Na, Ne, H and I) revealed moderate polymorphism and gene diversity in all populations of *M. dubia*. Comparatively, ISSR markers-based investigations by Rawat *et al*. (2018) found similar levels of genetic diversity indices in *M. dubia* (mean PPL= 50.77, H= 0.21 and I=0.30) in India. Moderate genetic diversity and population differentiation were also reported in *Melia azedarach*, a close kinship of *M. dubia* (Thakur et al 2016).

References

Rawat S, Arunkumar AN, Annapurna D, Karaba NN and Joshi G 2018. Genetic diversity of *Melia dubia* using ISSR markers for natural populations and plantations. *International Journal of Genetics* **10**(9): 490-494.

Thakur S, Choudhary S, Singh A, Ahmad K, Sharma G, Majeed A and Bhardwaj P 2016. Genetic diversity and population structure of *Melia azedarach* in North-Western Plains of India. *Trees* **30**(5): 1483-1494.

3.16/T_3-107

Survival, Growth and Biomass of *Bambusa tulda* Seedlings as affected by Different Level of Saline Irrigation Water

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Keywords: *Bambusa tulda,* saline water, irrigation, growth, survival

1. Introduction

Among different bamboo species in India, *Bambusa tulda* is now a days gaining popularity among farmers due to its versatile uses and culm characters. It is a widely used bamboo for commercial purposes in Bangladesh and India. Most of Bamboo species have moderate salt tolerance. Bamboo leaves are acidic in nature which reduces the salinity of the soil. Bamboos are potential species for reclamation of saline soils and water (Pulavarty and Bijaya, 2018). Bamboo species which can establish and survive in high TDS water can be useful in bamboo farming in areas of high TDS water. National Bamboo Mission, in consultation with industry and states has identified 10 crucial species to be encouraged to be planted by farmers and others to make the country self-sufficient in the supply of raw material to our industry. Among these 10 species, *B. tulda* had been selected for the present study.

2. Material and methods

The present investigation was carried out at Bamboo Resource Centre, College of Forestry, NAU, Navsari, Gujarat during the March- 2021 to June- 2022. The experiment was carried out in nursery conditions with completely randomized design. One year old seedlings of *B. tulda* were transplanted in to polybags size 18 cm x 18 cm having a mixture of soil and vermicompost in a ratio of 3:1. Total weight of plastic bags along with media was 12 kg. The sea water was collected from nearest seacoast *i.e.*, Dandi sea coast, which is having EC 38 dSm^{-1} and was diluted with normal water as per the treatments and stored. Initially seedlings were irrigated with normal water till survival and after 15 days, seedling were irrigated with five different levels of saline irrigation water *i.e.*, S_1: 0.5 dSm^{-1}, S_2: 2.0 dSm^{-1}, S_3: 4.0 dSm^{-1}, S_4: 6.0 dSm^{-1} and S_5: 8.0 dSm^{-1} at an interval of 2 days up to 120 DAT. The observations on survival, growth and biomass of seedling were recorded at 120 DAT.

3. Results and discussion

Survival of seedling was decrease with increase in salinity level of irrigation water. The maximum survival percentage of *B. tulda* seedlings 120 DAT was found in S_1: 0.5 dSm^{-1} (89.00 %) which was followed by S_2: 2.0 dSm^{-1} (84.67 %) and S_3: 4.0 dSm^{-1} (76.67 %). Seedling height was negatively affected by saline water, showing a reduction in height as increase in the salinity level of irrigation water. At 120 DAT, maximum seedling height was found in S_1: 0.5 dSm^{-1} (76.69 cm) which was at par with S_2: 2.0 dSm^{-1}(71.85 cm). Reduction in seedling height could be due to high concentration of soluble salts which increase the osmotic pressure and decrease the osmotic potential of soil solution which means that the soil water is held with extra energy produced by the presence of salts in *Leucaena leucocephala*, *Acacia nilotica* and *Casuarina equisitifolia* (Ali et al 1987). Number of leaves per seedling was registered maximum in S_1: 0.5 dSm^{-1} (96.46) which was on same bar with S_2: 2.0 dSm^{-1} (92.78) and S_3: 4.0 dSm^{-1} (89.78). Maximum number of shoots was reported in S_1: 0.5 dSm^{-1} (4.73) which was at statistically at par with S_2: 2.0 dSm^{-1} (4.53). At 120 DAT diameter of shoot registered maximum in S_1: 0.5 dSm^{-1} (5.47 mm) which was followed by S_2: 2.0 dS m^{-1} (4.16 mm). As the salinity level of irrigation increase the fresh and dry biomass of shoot and root affect adversely. Fresh biomass of shoot and root were recorded maximum in S_1: 0.5 dSm^{-1} (53.11 and 37.44 g, respectively) which was at statistically at par with S_2: 2.0 dSm^{-1} (5.23 and 33.52 g, respectively). In salinity level of S_3: 4.0 dSm^{-1} (44.45 and 15.23 g, respectively) marginal reduction in biomass was observed as compare to control and it was found lowest in S_5: 8.0 dSm^{-1} (14.95 and 5.82 g, respectively). Dry biomass of shoot and root are also found maximum in S_1: 0.5 dSm^{-1} (17.69 and 20.48 g, respectively) which was on same bar with S_2: 2.0 dSm^{-1} (16.96 and 19.60 g, respectively). In saline irrigation water of S_3: 4.0 dSm^{-1} (26.46 and 15.66 g, respectively) slight reduction in biomass was noted as compare to control and it was found lowest in S_5: 8.0 dSm^{-1} (8.09 and 4.60 g, respectively). The assessment of biomass clearly indicates that a significant increase in fresh and dry biomass was observed in seedlings treated with S_1: 0.5 dSm^{-1} as compared to different salinity levels. It was found that salinity stress caused significant decrease in total fresh and dry biomass at S_4: 6.0 dSm^{-1} and 8.0 dSm^{-1} as compared to seedlings treated with 0.5 dSm^{-1}. The higher level of salinity significantly reduced the survival percentage, seedling height, collar diameter, number of shoots per seedling, number of leaves per seedling, fresh and dry biomass of shoot and root in *B. tulda.* Among different level of saline irrigated water, significant reduction in survival, growth and biomass of *B. tulda* was registered at S_4: 6.0 dSm^{-1} and S_5: 8.0 dSm^{-1} while marginal reduction at S_3: 4.0 dSm^{-1}. However, S_1: 0.5 $dSm^{-1}$and S_2: 2.0 dSm^{-1} showed less impact on *B. tulda* seedling's survival, growth and biomass parameters. From the present study, it is inferred that *B. tulda* can be successfully grown with slight reduction in survival, growth and biomass up to the salinity level of 4 dSm^{-1}. It is also noticed that the critical limit of saline irrigation water under nursery condition for *B. tulda* is 4 dSm^{-1} which shows less negative impact on survival, growth and biomass as compared to higher salinity levels.

References

Ali S, Chaudary M A and Aslam F 1987. Growth of Leucaena at different salinity levels. Barani Agri. College, Rawalpindi, Pakistan. *Leucaena Res. Rep*. **8**: 53.

Pulavarty A and Sarangi B K 2018. Screening bamboo species for salt tolerance using growth parameters, physiological response and osmolytes accumulation as effective indicators, *Chemistry and Ecology*: 1-13.

3.17/T_3-108

Enhancement of Seedling Growth and Vigour using Biofertilizers in Anjan (*Hardwickia binata* Roxb.)

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Keywords: *Hardwickia binata*, biofertilizer, seedling, growth

1. Introduction

Hardwickia binata Roxb. is an endemic taxon to India, a handsome deciduous tree, with graceful drooping branchlets. This tree yields an extremely hard, heavy and durable timber, known in the trade as "Anjan". The wood is perhaps the hardest, heaviest in India. This tree can thrive in dry areas and even can withstand for prolonged drought. In spite of its excellent characters as a reforestation crop in drought prone areas, this tree is not planted extensively due to the difficulty in getting enough seedlings, as the seeds are prone to pathogenic attack during maturation. Biofertilizers are group of microorganisms consisting of bacteria, fungi, algae *etc.* These alone or in combinations are known to be increasing plant growth by way of various biochemical activities (Sharma and Chaubey, 2015).

2. Material and methods

The present investigation was conducted at Net house complex, College of Forestry, Navsari Agricultural University (NAU), Navsari, Gujarat, India. The growing media used was fine red soil, sand and FYM (Farm Yard Manure) in the ratio of 2:1:1. Seeds were sown in germination bed containing soil and sand for raising seedlings and then transplanted in poly bags containing above growing media. At three months stage, biofertilizers were applied to study the vigour of seedlings.

3. Results and discussion

The findings of present study showed that effect of biofertilizers such as Azospirillum and VAM on growth and development of Anjan (*H. binata* Roxb.) seedlings was found considerably maximum as compared to other treatments with respect to seedling height, collar diameter, number of leaves per plant, total leaf area per plant, root length, fresh and dry biomass as presented in the respective tables. Among various biofertilizers, Azospirillum significantly influenced the growth, biomass and vigour characteristics of Anjan (*H. binata* Roxb.) seedlings at initial growing stage. An application of Azospirillum @ 10 ml/plant (T_3) exhibited significantly maximum seedling height (25.47 cm), total leaf area (119.14 cm^2), fresh weight of shoot (0.84 g $plant^{-1}$), fresh weight of root (1.87 g $plant^{-1}$) and dry weight of root (0.74 g $plant^{-1}$) at 180 DAT. The maximum collar diameter (2.04 mm) and root length (43.82 cm) were recorded in T_7: pseudomonas @ 10 ml/plant and T_5: PSB @10 ml/plant, respectively at 180 DAT. The maximum dry weight of shoot (0.32 g) and root: shoot ratio (3.64) was noted in T_2: Azotobacter @ 10 ml/plant. However, at 180 DAT the lowest sturdiness quotient of 11.25 was found in T_5: PSB @10 ml/plant and significantly the maximum seedling quality index was recorded in T_3: Azospirillum @ 10 ml/plant. Overall result showed that an application of Azospirillum @ 10 ml/plant improved the growth and vigour of Anjan (*H. binata* Roxb.) seedlings at 180 DAT. Therefore, it can be used for raising and production of good quality seedlings in the forest nursery. Among various biofertilizers, Azospirillum and VAM were found to be most effective for enhancement of seedling growth and biomass and also increased quality of seedlings. Hence, the production of quality seedlings in Anjan (*H. binata* Roxb.) is done by using biofertilizers, Azospirillum and VAM.

Reference

Sharma A and Chaubey OP 2015. Biotechnological approach to enhance the growth and biomass of *Tectona grandis* Linn. F. (Teak) seedlings. *International Journal of Bio Science and Biotechnology* **7**(1): 19-28.

3.18/T_3-114

Influence of Biofertilizers on Early Stage Seedling Growth, Biomass and Vigour of *Anthocephalus cadamba* (Roxb.) Miq.

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Keywords: *Anthocephalus cadamba*, seedling growth, biomass, biofertilizer, VAM

1. Introduction

Anthocephalus cadamba (Roxb.) Miq., is fast growing and native species to India. *A. cadamba* has minimum shade effect and no allelopathic effect on the agricultural crop advocates its suitability for the agroforestry purpose, soil conservation and land reclamation. *A. cadamba* wood used in the manufacture of pencils, ceiling boards, commercial plywood, light construction work *etc*. Looking into the economical importance and to produce quality planting materials in nursery, the present trial was carried out to study the effect of biofertilizers on seedling growth and vigour of Kadam in early stage.

2. Material and methods

The present investigation was conducted at Net House, College of Forestry, NAU, Navsari, Gujarat. Seeds were sown in germination bed containing soil and sand for raising seedlings. After two months seedlings were transplanted into polythene bags containing growing media soil, sand and FYM (2:1:1) and after one month of establishment, different biofertilizers at the rate of 10 ml per plant were applied directly in the polythene bag. Observation for growth and vigour parameters were recorded at 150 DAT and data were analysed by adopting CRD design.

3. Results and discussion

The results of the present study showed that seedlings treated with VAM were superior, compared to other biofertilizer treatments, for collar diameter, root length, fresh and dry biomass and more importantly in SQI; however, it was found statistically at par for shoot length, number of leaves and leaf area with Azospirillum and root to shoot ratio and SQ with Pseudomonas. Present findings are in accordance with Sreedhar and Mohan (2016) in same species. Among all the biofertilizer treatments, VAM proved best for the growth and vigour of seedlings of *A. cadamba* in early stage and can be used for production of quality seedlings in forest nursery.

Table 1. Influence of biofertilizers on the growth and vigour parameters of *A. cadamba* seedlings at 150 DAT

Treatments	Shoot length (cm)	Collar diameter (mm)	Dry weight /plant (g)	Seedling Quality Index
T1: Control	65.40	7.47	13.99	1.11
T2: Azotobacter	68.22	8.43	16.99	1.50
T3: Azospirillum	80.52	8.90	18.25	1.46
T4: Acetobacter	74.73	8.45	17.89	1.47
T5: PSB	56.12	6.86	9.54	0.82
T6: Pseudomonas	57.31	7.61	8.42	0.80
T7: VAM	76.50	9.62	19.67	1.77
Mean	68.40	8.19	14.96	1.28
SEm(±)	1.78	0.13	0.42	0.03
CD at 5%	5.38	0.40	1.26	0.09
CV (%)	4.49	2.80	4.83	3.95

References

Sreedhar SS and Mohan V 2016. Effect of arbuscular mycorrhizal (AM) fungi and plant growth promoting rhizobacteria (PGPR) as bio-fertilizers on growth enhancement of economically important native tree species, *Neolamarckia cadamba* seedlings. *Kavaka* **47**: 125-133.

3.19/T_3-129

Variation in Morphology and Essential Oil Yield of Different Populations of *Tagetes minuta* L., in Garhwal Himalayas, India

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Keyword*:* *Tagetes minuta*, populations, morphological

1. Introduction

Tagetes minuta L. commonly known as wild marigold or jangli genda, is an annual herb, aromatic in nature (Sadia et al 2013). It is known for its essential oil present in flowers and leaves which has a unique aroma and several beneficial properties. The oil has huge market demand and is also increasing consistently (Walia and Kumar 2020).

2. Material and methods

T. minuta L. is an aromatic crop with huge demand having great industrial value. The variation in morphology and oil yield of *T. minuta* collected from different populations in Garhwal Himalaya was evaluated in this study. The mature phyllaries of *T. minuta* were collected from 14 populations across Garhwal Himalaya. The seeds were extracted from phyllaries and sown in polyhouse and later transplanted to field plots to study the variations among populations for their morphological and oil yield parameters.

3. Results and discussion

Results revealed that the populations of *T. minuta* were uniformly same in qualitative morphological features. However, significant variations ($p \leq 0.05$) were observed for quantitative morphological traits. Number of main branches per plant was the most variable character among the morphological traits. Yield parameters also revealed significant ($p \leq 0.05$) variations among different populations. The useful biomass, essential oil content and essential oil yield at full-flowering stage were 7.48, 52.04 and 55.16 % higher than pre-flowering. However, stem biomass at full-flowering stage decreased (8.25 %) as compared to pre-flowering stage. Significant and positive correlations were found between essential oil yield and plant height, collar diameter and leaf length at both the stages. Altitude did not affect morphological and yield parameters however, latitude and longitude had significant and positive relationship with some of them.

Table 1. Morphological and yield parameters of 14 populations of *T. minuta*

Populations	Plant height (cm)	Collar diameter (mm)	No. of primary branches/ plant	Leaf length (cm)	No. of leaflets/ leaf
Chinyali Saur	215.8	16.2	8.00	19.5	16.2
Kalsi	195.0	12.2	4.40	18.1	15.3
Uttarkashi	217.8	16.1	12.0	19.0	16.3
PipaliPani	205.0	14.6	6.00	16.6	13.5
Sainda	166.0	12.4	4.07	17.4	15.1
Dolinda	184.0	12.5	10.6	15.4	12.2
Palli	200.0	12.6	4.87	18.3	15.7
Koti	186.4	11.5	3.53	17.9	15.8
Gangnani	215.7	16.5	8.27	20.8	17.2
Dandachali	225.4	11.0	5.53	18.2	16.3
Mussorie	199.4	12.1	5.53	17.6	15.4
Barsu	225.8	17.8	9.47	19.5	16.8
Suwakholi	183.8	10.7	4.13	17.4	15.4
Kaddukhal	196.2	11.6	5.47	18.2	15.8
Mean	201.2	13.4	6.27	18.1	15.5
CD0.05	11.90	1.62	1.59	1.90	1.45

Populations	Pre-flowering stage				Full-flowering stage			
	Leaf portion			Stem	Flowering portion			Stem
	Fresh biomass (q ha^{-1})	Oil content (%)	Oil yield (l ha^{-1})	Fresh biomass (q ha^{-1})	Fresh biomass (q ha^{-1})	Oil content (%)	Oil yield (l ha^{-1})	Fresh biomass (q ha^{-1})
Chinyali Saur	67.1	0.24	16.3	338.8	66.7	0.43	28.7	316.7
Kalsi	44.6	0.26	11.4	186.6	56.8	0.53	30.1	180.6
Uttarkashi	65.8	0.24	15.8	362.9	62.6	0.54	33.8	338.1
PipaliPani	55.0	0.27	14.8	245.7	60.9	0.43	26.3	193.1
Sainda	40.7	0.23	9.54	156.2	40.4	0.51	20.6	138.4
Dolinda	48.6	0.20	9.73	268.9	52.5	0.42	21.9	205.3
Palli	56.6	0.24	13.4	204.8	62.1	0.43	26.7	192.7
Koti	29.3	0.20	5.77	206.5	50.3	0.52	26.1	190.2
Gangnani	64.1	0.27	17.5	341.2	69.1	0.57	39.6	320.1
Dandachali	57.3	0.25	14.3	212.1	67.3	0.50	33.4	210.6
Mussorie	46.4	0.20	9.29	237.7	44.8	0.47	21.1	226.6
Barsu	70.5	0.30	21.0	330.9	74.1	0.60	44.5	323.6
Suwakholi	53.4	0.27	14.2	189.0	49.7	0.52	25.9	174.0
Kaddukhal	54.7	0.20	10.8	228.6	57.8	0.55	31.7	210.2
Mean	53.9	0.24	13.1	250.7	58.2	0.50	29.3	230.0
CD0.05	8.48	0.04	3.09	16.76	7.34	0.02	3.74	12.81

References

Sadia S, Khalid S, Qureshi R and Bajwa AA 2013. *Tagetes minuta* L., a useful underutilized plant of family Asteraceae: a review. *Pakistan Journal of Weed Science Research* **19**(2): 179-189.

Walia S and Kumar R 2020. Wild marigold (*Tagetes minuta* L.) an important industrial aromatic crop: liquid gold from the Himalaya. *Journal of Essential Oil Research* **32**(5): 373-393.

3.20/T_3-133

Studies on Seed Germination and Seedling Growth of *Myristica dactyloides* in Relation to Stages of Fruit Maturity

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Keywords*:* Maturity, germination, seedling vigour index

1. Introduction

Myristica dactyloides is one of the non-swampy and dioecious tree species commonly known as "Gidda Ramapatre". The maturity time of the fruit has tremendous influence on seed quality, germination and seedling growth as well. Hence, the present study was carried out to collect information on the effect of seed collection time on seed germination and seedling behavior of *Myristica dactyloides*.

2. Material and methods

The fruits were collected at four stages of fruit maturity *viz*., Stage I (creamy white aril), Stage II (yellowish orange aril), Stage III (orange aril) and Stage IV (red aril) from Heggarni village of Janmane Forest Range of Sirsi Division. The extracted seeds were sown separately in nursery bed in a Completely Randomized Block Design (RCBD) with five replications considering four stages of maturity as the treatment. Observations were recorded at nursery stage for a period of three month after transplanting.

3. Results and discussion

The results showed statistically significant difference for all parameters *viz*., number of days for initiation of germination, germination per cent, mean daily germination, peak value, germination

Table 1. Effect of fruit maturity on germination parameters and seedling growth parameters of *M. dactyloides* at 3 MAT

Treatment	No. of days for germination initiation	G (%)	MDG	PV	GV
T_1(Stage I)	95.00	05.17	0.02	0.02	0.001
T_2(Stage II)	52.25	25.89	0.30	0.40	0.159
T_3(Stage III)	51.60	42.03	0.65	0.80	0.615
T_4(Stage IV)	47.60	58.66	1.15	1.33	1.617
SEm ±	1.42	5.15	0.09	0.11	0.226
$CD_{0.05}$	4.43	16.04	0.28	0.34	0.705

Table 1. contd…

Treatment	Seedling height (cm)	Collar diameter (mm)	Shoot length (cm)	Root length (cm)	No. of leaves	Seedling Vigour Index
T_1 (Stage I)	18.90	2.92	6.53	12.37	2.67	97.71
T_2(Stage II)	24.34	4.23	10.77	13.57	3.15	630.16
T_3(Stage III)	27.91	4.59	13.33	14.58	3.25	1173.06
T_4(Stage IV)	30.28	5.22	14.01	16.27	5.00	1776.22
SEm ±	0.50	0.08	0.29	0.28	0.12	66.11
$CD_{0.05}$	1.52	0.23	0.90	0.84	0.37	201.08

Note: MDG – Mean daily germination, PV – peak value, GV – Germination value, MAT - Months After Transplanting value, seedling height, shoot length, collar diameter, root length, number of leaves and seedling vigour index. It is very interesting to notice that T_4 (Stage – IV) showed significantly superior values for all parameters. It can be concluded from the study that Stage IV (red aril) was the best stage for collection to get a higher germination and seedling vigour index. The results obtained were in line with study conducted by Prabhugoud (2015), where he reported that germination and seedling vigour index of *Myristica malabarica* showed higher performance in final collection stage (2nd fortnight of February).

Reference

Prabhugoud I B 2015. Studies on seed maturity, seed storage on germination and integrated nutrient management on seedlings growth of *Myristica malabarica* Lam. *M.Sc. (For.) Thesis*, University of Agricultural Sciences, Dharwad, Karnataka, India.

3.21/T_3-138

Variation in Fruit and Seed Traits Among Different Accessions of *Sterculia urens*

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Keywords: *Sterculia urens*, fruit traits, seed traits

1. Introduction

Gum Karaya (*Sterculia urens* Roxb.) is one of the commercial important NTFP tree species distributed in tropical deciduous forests of dry rocky hill lands. Tree exudates gum called Karaya gum or Indian-tragacanth. Purified gum is used in foodstuffs as emulsifiers/stabilizers, as thickeners in cosmetics and medications, and as an adhesive for dentures. Therefore, collection of gum karaya is providing income to the tribal community. Understanding variability for fruit/seed attributes and other economic traits is most important for under-domesticated tree species. Hence, a study was proposed to record variability in fruit, seed and germination of *S. urens.*

2. Material and methods

In the present study, total 14 trees (Accessions) distributed in the Vansda forest, Gujarat, India, were selected and matured fruits were collected from marked trees during April to May. Various fruit and seed traits were measured in the laboratory of College of Forestry, Navsari Agricultural University, Navsari. Further, germination trial was undertaken using 14 accessions and daily germination count was recorded. Genetic parameters were worked-out for seed traits and germination (Bhuva 2016; Bhuva et al 2019).

3. Results and discussion

Intra-population variation for fruit/seed traits was recorded in *S. urens.* Number of fruits per inflorescence varied from 3.22 to 5.56. Significant variation ($P<0.05$) among different accessions for

Table 1. Intra population variation for fruit and seed traits of *Sterculia urens* in Vansda forest of south Gujarat

Tree ID	Fruit length (mm)	Fruit thickness (mm)	Fruit weight (g)	Seed length (mm)	Seed thickness (mm)	Seed weight (g)
VNP-01	38.11	18.17	1.87	9.58	6.05	0.19
VNP-02	35.34	16.30	1.98	9.35	6.32	0.24
VNP-03	41.84	18.53	2.56	10.81	6.57	0.29
VNP-04	39.67	17.53	2.24	10.52	6.91	0.28
VNP-05	37.16	16.26	1.84	11.56	6.15	0.29
VNP-06	29.30	18.68	2.31	11.01	6.73	0.29
VNP-07	43.29	19.53	2.48	10.66	6.47	0.27
VNP-08	36.66	14.60	1.05	9.26	5.33	0.12
VNP-09	-	-	-	9.82	6.39	0.23
VNP-10	-	-	-	10.49	6.46	0.29
VNP-11	30.79	19.70	2.13	10.05	6.35	0.24
VNP-12	-	-	-	8.57	6.53	0.22
VNP-13	-	-	-	9.41	5.81	0.18
VNP-14	-	-	-	9.70	5.98	0.21
Mean	36.91	17.70	2.05	10.06	6.29	0.24
SEm (±)	2.6	0.77	0.18	0.13	0.08	0.01
$CD_{0.05\ P}$	7.71	2.29	0.53	0.37	0.23	0.03
CV (%)	11.78	7.56	15.25	3.25	3.29	9.78

Note: Data is not given in five trees due to insufficient collection fruit length (29.30-43.29 mm), fruit thickness (14.60-19.70 mm) and fruit weight (1.05-2.56 g) was recorded (Table 1). The number of seeds per fruit ranged between 3.40 and 4.77. Seed traits *viz.*, length (8.57-11.56 mm), thickness (5.33-6.91 mm) and single seed weight (0.12-0.29 g), as well as seed germination (53.33 to 100%) varied significantly among accessions ($P< 0.05$). Six of fourteen accessions resulted in > 90% germination. Seed length (86%) and seed weight (81%) recorded maximum heritability values; however, seed weight (38.50%) and germination (30.86%) recorded with maximum genetic gain. Study revealed that seedlots collected from different accessions exhibited great variation in fruit & seed attributes as well as germination (%); therefore, there is a scope for further selection and improvement of this species from Vansda forest area.

Reference

Bhuva DC 2016. Stand structure and intra-population variation for seed and seedling characteristics in *Sterculia urens* Roxb. M.Sc. Thesis submitted to Navsari Agricultural University, Navsari, Gujarat.

Bhuva D C, Gunaga R P, Thakur N S and Bhusara J B. 2019. Seed and germination attributes in *Sterculia urens* Roxb. populations in south Gujarat. *Journal of Tree Sciences,* 38(1): 23-27.

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Structure and Variability of *Hydnocarpus pentandrus* populations in Central Western Ghats

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Keywords: *Hydnocarpus pentendrus,* seed treatment, fruit maturity, population

1. Introduction

Hydnocarpus pentendrus (Family Achariaceae) is an important and rare medical tree species distributed in Western Ghats of India. Ecologically this species is a part of moist deciduous and semi-evergreen forests of Western Ghats, distributed upto 850 MASL (Joshi and Harijan 2014) and found to grow near moist and shady localities**.** *Hydnocarpus* sp. are threatened world-wide are known for their ecological and economic significance in the tropical evergreen forest (Manjunath et al 2010). The seed yields chaulmoogra oil of commerce and is used for skin care and leprosy treatment.

2. Material and methods

The present study was conducted to assess the distribution of *H. pentendrus*in Western Ghats. Variations among the populations for fruits traits and Phenological studies were carried out during 2021-22 for *H. pentendrus* in Ratnagiri and Sindhudurg District. Seed oil content was analysed by soxhelt method and traditional method.Seed propagation technique was standardized, in this a total eight treatments were imposed to ascertain germination.

3. Results and discussion

A total of eight populations of *H. pentendrus* were selected from study on the basis agro-climatic zone in Sindhudurg and Ratnagiri District. It was observed that all the populations are found near stream in private farm and scared grooves. It was observed that all trees had more than 140 cm GBH with the age of 30-80 years. The fruit maturity period is about 12-13 Months in all the populations. All fruits parameter *i.e.,* length, width and weight varied significantly, however, seed parameter varied non-significantly. In the present investigation, different pre-sowing treatments *viz*.,T_1- scarification (control), T_2 - Soaking seed in cold water for 24 hours, T_3 - Soaking seed in GA_3@ 350 ppm for 24 hours, T_4 - Soaking seed in GA_3 @ 300 ppm for 24 hours 350 ppm, T_5 - Soaking seed in H_2SO_4 1.0%, T_6 - Soaking seed in $H_2SO_4$2.0%, T_7 - Goat manure + soil and T_8 - Goat manure + coco-peat were undertaken.In the mixture of goat manure + cocopeat the germination was observed more (76%) and in the mixture of goat manure+soil (68%).

References

Joshi AB and Harijan KC 2014. Physicochemical and Phytochemical investigation of the roots of *Hydnocarpus pentandrus* (Buch.- Ham.) Oken. *International Journal of Pharmaceutical Sciences Review and Research* **25**(1): 260-265

Manjunath GO, Patil SK, Shivanna H and Rathod RS 2010. Standardization of propagation techniques in Garcinia indica L. Chociy. **In:** Vasudeva, R., Janagoudar B.S., Reddy, B.M.C., Bhuwaon Sthapit and H.P. Singh, (Eds.), Garcinia Genetic Resources, *College of Forestry, Sirsi, India*. pp 122-127.

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Clonal Variation for Growth in Clonal Seed Orchard of Teak (*Tectona Grandis* Linn.)

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Keywords: Teak, clonal seed orchard, genetic variation,

1. Introduction

Tectona grandis Linn. f., also known as Teak, is a forest tree species of the Verbenaceae family that naturally grows in India, Laos, Myanmar, and Thailand. It thrives mostly in areas with mean annual rainfall of 1,000 to 1,500 mm and a distinct dry season. Teak wood is versatile and has a wide range of applications, from furniture making to shipbuilding, as both sawn-timber or veneer (Tewari 1992; Bhat 2000). Variability study is first step in tree improvement programme. This paper focuses of variability among 20 teak clones in a clonal seed orchard of Gujarat.

2. Material and methods

The present investigation was carried out in a 25 years clonal seed orchard (CSO) of *Tectona grandis* raised at Manch circle, Dediyapada (Gujarat), established in year 1997-1998 by Gujrat Forest department. The experimental material comprised of 20 clones of the *T. grandis* planted at the spacing of 5 m × 5 m in randomized block design (RBD). The observations were recorded on tree height (m), diameter at breast height (cm), clear bole height, crown spread and tree volume (m^3).

3. Result and discussion

Result showed that there was a significant variation for all the observed parameters. The maximum tree height (13.71 m) and diameter at breast height (74.33 cm) was observed in Clone no 13, whereas the maximum clear bole height (7.63 m) and crown spread (2.57 m) was observed in Clone 3. However, the lowest values for height (11.60 m) were observed in Clone 4. The minimum clear bole height (6.06 m), DBH (52.44 cm) and crown spread (1.83 m) was recorded in Clone 1. Overall, Genotype 18 exhibited highest stem volume which was 2.95 m^3.

References

Bhat KM 2000. Timber quality of teak from managed plantations of the tropics. *Bois et Forêts des Tropiques* 263: 6-16.

Tewari DN 1992. A monograph on teak (*Tectona grandis* Linn. f.). International book distributors.

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Growth Variation in Clonal Seed Orchard of Sissoo (*Dalbergia Sissoo* Roxb).

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Keywords*: Dalbergia Sissoo,* clonal seed orchard,

1. Introduction

Dalbergia sissoo, commonly known as 'Sissoo,' is a plant in the Leguminosae or Papilionaceae family. It is a valuable indigenous versatile tree species in northern India. The species is found across the sub-Himalayan region, from the Indus to Assam. *D. sissoo* has higher timber value and is classified as one of the four primary timbers of India, the others being Teak, Sal and Deodar. The wood is brown, very hard, strong, and durable, possessing beautiful natural gain.

2. Material and methods

The present investigation was carried out in a clonal seed orchard (CSO) of *Dalbergia sissoo* raised at Manch circle, Dediyapada (Gujarat). The experimental material comprised of 16 clones of *Dalbergia sissoo* and was collected from diverse locations. The clones were planted at the spacing of 5 m × 5 m in randomized block design (RBD) with one block and it consist fifty row of lines and each line consist sixteen genotypes. The clones were 25 years of age at the time of study.

3. Results and discussion

Result showed that there was a greater variation among genotypes for phenotypic growth characters. The height ranged between 11.93 to 13.45 m, DBH between 47.67 to 61.75 cm, crown spread between 3.5 to 4.67 m, whereas the tree volume ranged between 1.12 to 2.10 m^3. The highest height (13.45 m), DBH (61.75 cm) and tree volume (2.10 m^3) was observed in clone 16, whereas maximum crown spread (4.67 m) was observed in Clone 9. Overall, Clones G4, G7, G9, G12, G13 found best for volume production and can be selected for establishment of advance generation seed orchard and inclusion in breeding population of *D. sissoo* improvement programs.

Reference

Vakshasya RK, Rajora OP and Rawat MS 1992. Seed and seedling traits of *Dalbergia sissoo* Roxb.: seed source variation studies among ten sources in India. *Forest Ecology and Management* **48**(3-4): 265-275.

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Intra-Population Variation in Mahua (*Madhuca longifolia* var. *latifolia* Roxb. A. Chev.) for Fruit, Seed and Germination Traits

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Keywords: *Madhuca longifolia,* population variation, germination

1. Introduction

There is a great demand for seeds and flowers of mahua for commercial purpose and required raw materials come from natural sources. Intra specific variation leads trees to show better phenotypic characters, resistance against the harsh conditions and biological agents. These characters would help to screen the best genotypes for the specific purpose. There is gap in information about intra-population variation for morphometric distinction in fruit, seed and germination attributes in mahua (*Madhuca longifolia* var. *latifolia* Roxb. A. Chev.) and their correlation. Therefore, to fulfill some of these gaps in intra-population, variability studies in this high value tropical tree species was undertaken.

2. Material and methods

For this study, total ten accessions were selected in the focal population of mahua situated at Makadaban forest area of Dharampur taluka of southern Gujarat which is located in northern Western Ghats. Matured fruits of mahua were collected during June. Seedlots of individual tree identity was maintained and they were used for study. Data on various quantitative traits of fruits and seeds like length, thickness and weight were recorded for all the accessions. Germination experiment was carried out in the nursery under shade-net area. Seedlings were raised in nursery in CRD to assess the seedling vigour.

Table 1. Variation in seed traits of *M. longifolia* var. *latifolia*

Open pollinated mother trees	Seed length (mm)			Seed thickness (mm)			Seed weight (g)		
	Year -1 (2015)	Year-2 (2016)	Pooled	Year -1 (2015)	Year-2 (2016)	Pooled	Year -1 (2015)	Year-2 (2016)	Pooled
MLLMG-1	30.56	29.50	30.03	17.06	12.19	14.63	4.60	3.44	4.02
MLLMG-2	26.42	32.60	29.51	14.70	15.18	14.94	2.84	5.05	3.95
MLLMG-3	33.26	32.90	33.08	18.95	14.03	16.49	5.26	5.09	5.18
MLLMG-4	29.64	31.70	30.67	17.87	14.37	16.12	5.14	4.91	5.03
MLLMG-5	25.08	29.30	27.19	16.65	13.48	15.07	3.74	3.72	3.73
MLLMG-6	26.00	31.60	28.80	16.25	11.35	13.80	3.69	3.56	3.63
MLLMG-7	25.66	25.30	25.48	17.93	11.40	14.67	4.55	2.99	3.77
MLLMG-8	28.10	31.40	29.75	15.22	13.02	14.12	3.59	3.79	3.69
MLLMG-9	29.92	25.40	27.66	16.46	15.27	15.87	3.98	2.96	3.47
MLLMG-10	28.30	29.60	28.95	16.06	15.49	15.78	3.95	3.28	3.62
Mean	28.29	29.93	29.11	16.72	13.58	15.15	4.13	3.88	4.01
SEm (±)	0.30	0.43	1.65	0.17	0.31	1.12	0.07	0.18	0.51
CD @ 5%	0.86	1.24	NS	0.48	0.90	NS	0.20	0.51	NS
CV (%)	2.35	3.24	2.85	2.23	5.17	3.63	3.78	10.18	7.49
SEm (±) (YxT)	-	-	0.37	-	-	0.24	-	-	0.13
CD @ 5% (YxT)	-	-	1.06	-	-	0.70	-	-	0.38

3. Result and Discussion

Various fruits and seed traits like length, thickness as well as weight showed significant variation among 10 studied individuals. Among ten individuals, trees coded with MLLMG-3, MLLMG-4 and MLLMG-1 yielded bigger and bolder seeds than other trees; in fact, seed weight of these trees were almost double than seeds of MLLMG-2 tree. Germination and its parameters also showed significant variation among ten individuals, where germination ranged between 56.25 and 93.00 per cent. However, mean germination time ranged from 15.33 to 18.95. It is divulged that the overall increment of seedling height and collar diameter was 5.84 cm and 2.80 mm, respectively within six months, where seeds collected from MLLMG-1 tree resulted in highest seedling growth and biomass, followed by MLLMG-4. Variations in the fruit and seed sizes could be due to genetic potential among the selected individuals or it may be due to the differences in microsite environmental as well as edaphic factors in which the mother trees grow. On other hand, the character of maternal and paternal parent also influences seed and seedling traits due to the nature of cross pollination in forest species. Study revealed about the existence of strong within-population variation for various fruit, seed, germination and seedling vigour attributes in mahua ($P<0.05$). Therefore, further selection and improvement work can be done on this species for production of quality seeds in large quantity to fulfill various demands.

References

Gunaga RP, Manjunath AV, Gunaga SV and Vasudeva R 2015. Tree to tree variation in seed traits and germination in *Dysoxylum binectariferum* Hook.F. *The Indian Forester* **141**: 578-580.

Khurana E and Singh JS 2001. Ecology of tree seed and seedlings: Implications for tropical forest conservation and restoration. *Current Science* **80**:748-757.

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Promising Eucalyptus Clones for Vindhyan Region of UP, India

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1. Introduction

As a short rotation and fast-growing nature, Eucalyptus is widely preferred by farmers for pulp paper and plywood industries as well as in local market for poles. In eastern Uttar Pradesh, eucalypts are in improving stage for adoption at larger level and choice of suitable clones in plantations is still a big challenge for them. Thus, the main objective of this study was to assess the growth performance of Eucalyptus clones in Vindhyan region of Mirzapur district for identification of promising clones .

2. Material and methods

An experimental trial was established in the year 2016 with 19 commercial clones at spacing of 2x3 meter in randomized block design in Mirzapur. The annual increment of each clone was calculated using all the growth parameters (girth at breast height; GBH and height) for consecutive five years. The basal area in m^2 (BA =0.00007854 x DBH in cm) and volume of trees in cum ($V= \pi r^2 x h$) / tree (r and h in m), (1667 trees / ha in 3x2 spacing) were also calculated. The data were statistically analysed by standard ANOVA techniques (XLSTAT).

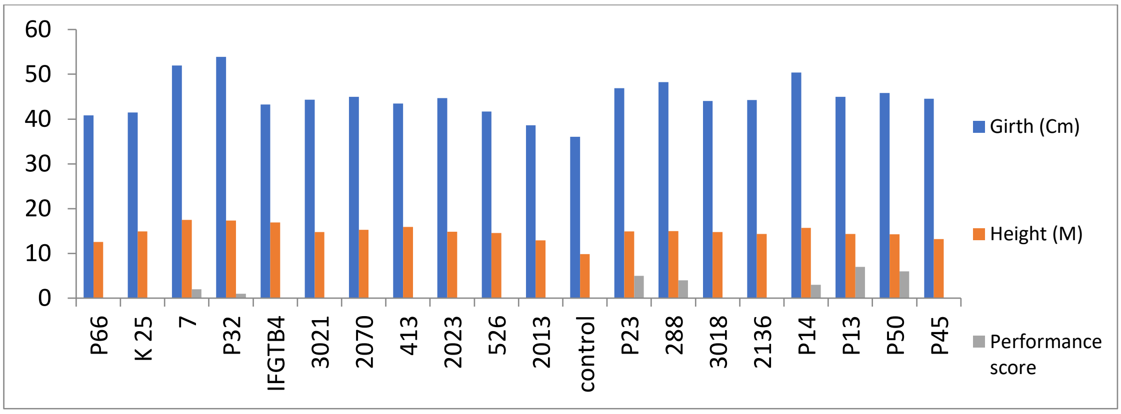

Fig. 1. Growth performance of clones after five years of planting in Mirzapur

3. Results and discussion

The highest value of increment in GBH belonged to clones P-32 (53.88 cm) followed by 07 (51.96 cm), P-14 (50.40 cm), 288 (48.24 cm), P-23 (46.89 cm), P-50 (45.79 cm), and P-13 (44.99 cm) after five years of planting. The clones with good annual increment in height were 07 (17.50 m) followed by P-32 (17.33 m). On the basis of growth parameters, *viz.* height, girth at breast height, basal area and tree volume, clone P-32, 07, P-14, 288, P-23, P-50 and P-13 were promising over others (Fig.1).All superior clones belonged to species *E. camaldulensis* except 288 and 07 which were of *E. tereticornis*. The results of the analysis of variance (ANOVA) for mean height and girth increments showed high levels of significance. Similarly, in south Gujrat, clonal variation for growth parameters such as DBH, mid-diameter, height, form quotient and volume was significantly different among 20 clones of Eucalyptus and DBH varied between 11.47 and 16.07 cm with an overall mean of 13.28 cm (Behera 2016).

References

Behera LK 2016. Clonal variation in physical, anatomical and chemical properties of wood of Eucalyptus. *Ph.D. Thesis*, Navsari Agricultural University, Navsari, 215.

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Estimates of Genetic Variation in Wood Mechanical Properties among *Eucalyptus* Clones

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Keywords: Eucalypts, clonal variation, static bending, compressive strength, tensile strength

1. Introduction

Eucalyptus is a major forest tree species suitable for production of pulp, paper and poles. Moreover, there is always a great demand for high productive genotypes that provide good strength as pole. Testing of wood mechanical properties is essential to know the suitability of timber for various end uses. Hence, the present investigation was undertaken to identify superior clones for pole.

2. Materials and methods

The present investigation was carried out at Navsari (20.95^0 N latitude, 75.90^0 E longitude, 12 m. MSL and annual rainfall 1355 mm) during 2014-15 to 2016-2017 with 18 *Eucalyptus* clones for four years following Randomized Block Design. A total 6 trees/clone were used for assessment of genetic variation for wood mechanical properties. Wooden samples were collected and tested as per Indian Standard Specification IS 1708 (Part 1-18):1986 using Universal Testing Machine (UTM) of 50 kN capacity.

3. Results and discussion

Analysis of variance studied for mechanical properties such as static bending strength, tensile strength parallel to grain showed significant variation among 18 clones, except compression strength parallel to grain (Table 1). Static bending for MOE ranged from 667.08x10^2 to 1320.81x10^2 kg cm^{-2}.

Table 1. Clonal variation for wood mechanical properties among 18 *Eucalypts* clones at 4 years age

Clone	Compression strength parallel to grain [MCS (kg cm^{-2})]	Tensile strength parallel to grain [TS at ML (kg cm^{-2})]	Static bending	
			MOE (10^2 kg cm^{-2})	MOR (kg cm^{-2})
EC-1	445.60	960.36	1023.30	857.73
EC-2	546.05	869.38	1086.45	1046.28
EC-3	539.53	871.00	991.51	900.87
EC-4	529.14	1250.20	1025.25	962.51
EC-5	535.81	1001.46	976.95	1107.61
EC-6	546.21	751.46	1135.79	1106.49
EC-7	509.72	1024.08	905.25	963.35
EC-8	582.68	985.83	972.06	1039.92
EC-9	529.01	967.95	935.62	1178.06
EC-10	581.92	1004.46	915.56	951.59
EC-11	549.01	1149.51	911.12	965.24
EC-12	592.77	1184.8	1320.81	1527.32
EC-13	454.56	940.49	908.95	874.88
EC-14	461.66	775.34	786.41	1020.03
EC-15	473.82	911.57	851.52	1016.77
EC-16	495.37	999.47	848.90	782.70
EC-17	532.59	849.57	841.92	973.59
EC-18	472.58	904.33	667.08	814.69
Mean	521.00	966.74	950.25	1004.98
SEm (±)	33.79	61.41	4736.29	50.08
CD ($P \leq 0.05$)	NS	176.84	13639.76	144.23

For MOR, it was ranged from 782 to 1527 kg cm^{-2}. Tensile strength varied from 751.46 to 1250.20 kg cm^{-2} with overall mean 966.74 kg cm^{-2}. Maximum crushing stress varied from 445.60 to 592.77 kg cm^{-2} was at par with results reported by Pima (2015), Olufemi and Malami (2011), Bal and Bektas (2013). Our result showed that among 18 clones, EC-4, EC-5, EC-8, EC-11 and EC-12 clones showed superior wood quality for strength properties and hence these clones can be utilized in pole for various structural applications. Moreover, these clones may be used for commercial plantations and also for further breeding programme to obtain higher productive potential.

References

Olufemi B and Malami A 2011. Density and bending strength characteristics of North Western Nigerian grown *Eucalyptus* camaldulensis in relation to utilization as timber. *Research Journal of Forestry* **5**(2): 107 - 114.

Pima NE 2015. Growth performance, water use and wood properties of eucalypt clones in Tanzania. Ph.D. Thesis. Sokoine University of Agriculture, Morogoro, Tanzania.

3.28/T_3-197

Variation for Growth Parameters among Half-Sib Progenies of *Cinnamomum Zeylanicum* Blume.

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Keywords: *Cinnamomum Zeylanicum,* progeny, growth, variety

1. Introduction

Cinnamomum zeylanicum Blume., commonly known as *Dalchini*, has recently gained attention because of its therapeutic values in treating diabetes. Karnataka is endowed with populations of cinnamon trees in widely varying environments, there are scant attempts to select plus trees. There are no released varieties of cinnamon in the state. This report was first-ever half-sib progeny field trial data for growth traits in Northern Karnataka.

2. Materials and Methods

The study area consists of one germplasm conservation site in Bakkal Botanical Garden near Hulekal, Sirsi. The experiment was laid out in RCBD design with three replications. The following 15 progenies *viz.,* J2 and J6 from Jaddigadde, Sirsi, Uttara Kannada; G4, G11, G16 and G24 from Gejjehalli, Hangal, Haveri; K5, K10, K13, K16 and K18 from Kankodlu, Yellapura, Uttara Kannada and S1, S4, S5 and S9 from Siddapura, Siddapura, Shimoga were tested. Measurement of seedling growth parameters such as plant height (cm), girth at collar region (mm), number of leaves per plant, number of branches per plant recorded manually after two years of planting.

3. Results and discussion

The maximum plant height was observed in the G4 (231.66 cm) followed by the K13 (222.66 cm) family (Table 1). The maximum girth at the collar region was observed in G11 (59.78 mm), the greater number of leaves per plant were found in the G11 and S1 (690.66) family, respectively and the lowest number of leaves per plant was found in the K18 (193 family); However, the greater number of branches per plant was observed in the S4 (58.33) family.

Table 1. Variation in growth parameters (Mean±SE) among half-sib progenies of *C. zeylanicum* at 32 months after planting (MAP)

Family I. D	Plant height (cm)	Collar girth (mm)	No. of leaves/ plant	No. of branches/ plant
J2	186.66±20.27	50.67±3.20	391.00±34.93	36.66±5.89
J6	173.33±18.55	38.44±4.26	433.33±77.84	36.33±4.80
G4	231.66±14.53	51.00±5.17	261.33±79.23	43.33±7.51
G11	216.00±21.96	59.78±4.21	690.66±86.20	57.00±1.15
G16	159.66±28.88	32.60±5.77	253.00±69.25	30.66±2.84
G24	137.66±40.13	33.63±4.98	205.00±72.77	40.66±8.00
K5	155.00±30.66	41.13±2.99	444.66±25.30	19.66±1.66
K10	198.33±10.20	40.95±6.11	373.66±52.91	35.33±7.21
K13	222.66±25.40	47.94±8.45	343.00±42.46	35.66±6.64
K16	210.66±20.89	54.00±5.85	462.66±42.31	45.33±6.56
K18	138.33±23.39	26.50±4.76	193.00±14.29	36.66±8.57
S1	188.33±10.13	41.56±4.74	690.66±194.63	51.66±9.33
S4	167.00±11.06	49.39±2.38	553.33±75.72	58.33±7.79
S5	173.66±18.16	36.15±5.64	355.66±37.54	57.00±5.03
S9	205.66±7.96	32.95±1.54	345.00±7.37	44.00±3.51
SEm±	21.62	5.06	75.59	6.48
CD@5%	NS	14.74	220.13	18.88
CV (%)	20.32	20.65	32.75	26.81

NS = Non-significant

3.29/T_3-201

Do the Geo-Climatic Variables Shape the Morphological Plasticity Pattern in *Melia dubia* Cav. Natural Populations?

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Keywords: *Melia dubia*, climatic variable, morphology, fruit traits

1. Introduction

Morphological characteristics are determined by inherited genetic information and environmental and geographical conditions *Melia dubia* is an indigenous tree species that caught attention of researcher due to its fast growing nature, broader industrial uses, and thus economic prospects. We investigated the morphological variation in foliar and fruit traits of *M. dubia* and attempted to understand how the geo-climatic gradients play a role in shaping these traits.

2. Material and methods

Four natural populations of *M. dubia* were selected from the Kaprada and Nanapondha regions of Valsad district, Waghai region of the Dangs, and the Sagai region of Narmada district in Gujarat. The study included ten individuals from each population. Six fresh leaves and sixty drupes per individual were examined for morphological variations. Morphological difference were analysed with univariate and multivariate techniques. Correlation of morphological traits with geo-climatic variables was worked out.

3. Result and discussion

Our study quantified the variations in foliar and fruit traits among selected natural populations of *M. dubia* in Gujarat, India. The population of *Sagai* region (SG) was superior for foliar traits, and the rest of the population did not significantly differ from each other. Populations from *Kaparada (KP)* and *Nanapondha (NP)* had *at par* finer fruit traits. The observed differences in morphological traits might be adaptations to geo-climatic differences. A good fit plot established that morphological variations exist among the population along latitudinal and altitudinal gradients. Furthermore, the study population's foliar and fruit traits were found to be strongly influenced by mean temperature and rainfall. Out of all the geo-climatic variables, rainfall explained the highest morphological variability in PC1, making it the most important selection pressure for shaping morphological elasticity.

References

Chauhan RS, Jadeja DB, Thakur NS and Jha SK 2021. Variability in stone characters and early progeny performance of selected genotypes *Melia dubia* from Northern Western Ghats of India. *Indian Journal of Ecology* **48**(4): 1032-1038.

Ramachandran A and Vasudeva R 2020. Clinal variation for fruit, seed and leaf morphological characteristics in natural populations of *Pyrenacantha volubilis* Wight: a rich source of anti-cancer drug. *Journal of Farm Science* **33**(1): 125-130.

4.1/T_4-01

Briquettes from Wood Waste: A Source of Renewable Energy

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Keywords: Wood waste, renewable energy, briquette, pyrolysis

1. Introduction

The growing concerns of climate change and limited availability of fossil fuels, the wood is regaining its significance by many responsible countries. In India, a huge amount of biomass is produced every year comprising the residues from crop, used furniture, industrial waste and temporary houses at construction site. These can be alternatively used for briquettes manufacturing for generating energy worldwide.

2. Source of wood waste

The waste could be in the form of bark, sawdust, chips, coarse residues, shavings, planer peel and end trimmings generated during the industrial processes (Berger et al 2020). The average biomass generated from agricultural and forest as a waste in European countries was found to be 242 million tonnes (Mt) in 2010, and it is expected to increase to 280 Mt by 2030 (Figure 1). An estimate form Wood Recyclers Association 2021, revels that Germany alone produced 11.90 million tonnes of wood wastes from wood packaging, demolition and construction, wood processing industry. Large quantities of waste wood generated in residential, commercial and industrial sources as a container or packaging material.

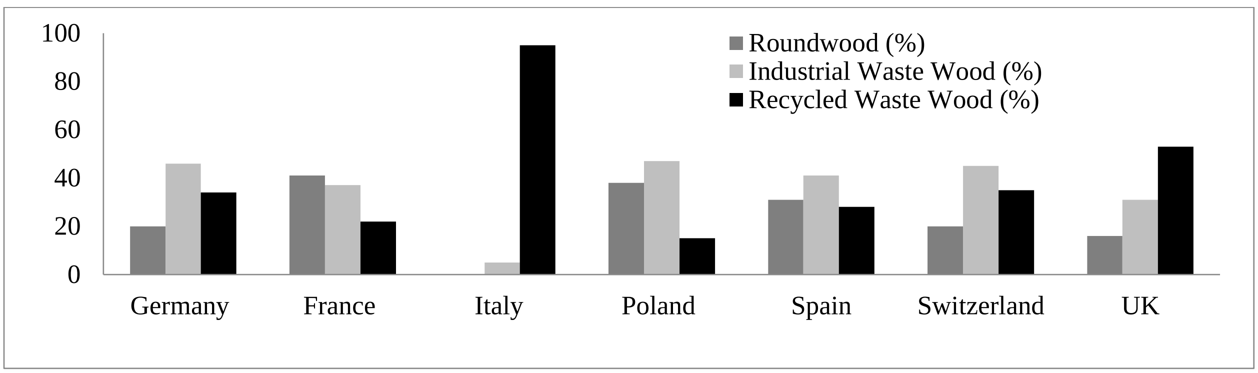

Figure 1. Waste wood generated in European countries in year 2015

3. Briquette manufacturing Technique

Briquette manufacturing process is simply a densification process that produces a uniform fuel with high energy density and reduces the transport and handling costs of the bulky biomass. There are several techniques being used worldwide which can be classified as follows: piston press, screw press, hydraulic press and roller press. Pyrolysis is considered as the safest way of getting green energy from wooden materials. The major benefit of the pyrolysis process includes the lower heating temperature requirements, less equipment investment, and the production of by-products like liquid phase bio-oil. Thousands of metric tons of wood waste are generated as a result in the form of used furniture, municipal wastes and industrial waste. Utilizing this wood waste and transforming into valuable products is not only conserving our natural resource but a genuine disposal of waste material.

Reference

Berger F, Gauvin F and Brouwers HJH 2020. The recycling potential of wood waste into wood-wool/cement composite. *Construction and Building Materials* **260**: 119786.

4.2/T4-02

Estimating Population Density and Factor affecting Occupancy Pattern of Himalayan Musk Deer (*Moschus leucogaster*) in Shey Phoksundo National Park

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Keywords: Musk Deer, population density, pellet, footprint, trails

1. Introduction

Himalayan Musk deer (*Moschus leucogaster*) is a shy solitary species, distributed in Afghanistan, Bhutan, China, India, Myanmar, Nepal and Pakistan. In these areas, it inhabit Alpine forest, between elevations of 2,200 to 4,300 meters with moderate to steep slopes, having vegetation type like oak, fir, rhododendron, blue pine, juniper, grass, lichens and scrub.

2. Material and methods

For preliminary survey, 10 m belt transects were laid in the forest 5 m abreast of the trail and each site was exhaustively searched in mid-March along the counter. Study area was divided into spatial sub-units with the array of square-shaped grid cells measuring 3x3 km^2 each. Each grid had at least 2 spatial transects of each average length 820 m. In each transect, we noted direct sighting & indirect evidence (pellet piles, resting site, footprint and trails).

3. Results and discussion

It was estimated that the population density of musk deer is approximately 7 per 10 km^2. Out of the total 236 signs, the pellet has the highest frequency of occurrence (59%). The average encounter rate of the pellet was 4.37 signs per kilometer. Nearly 61 per cent of the signs were fresh signs (< 15 days old).

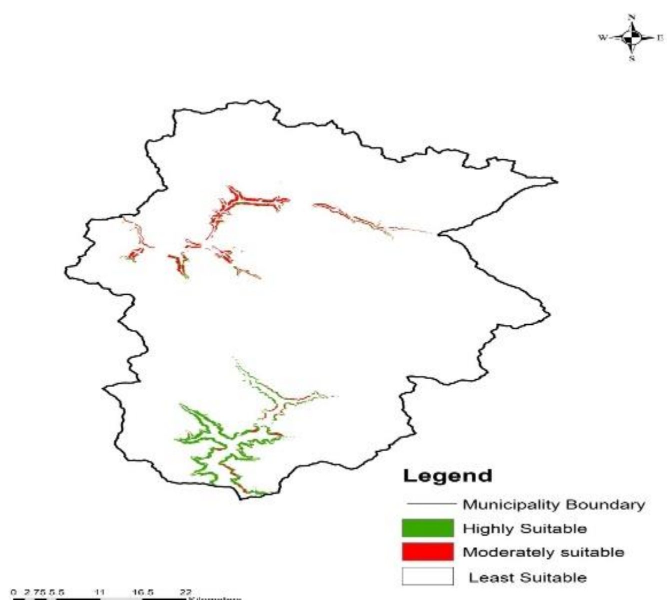

Figure 1. Possible distribution habitat of Himalayan Musk Deer in Phoksundo Rural Municipality

Based on the sign encounter rate, musk deer seems to occur more frequently in the hill slope (3200-3500 m) elevation category. Factors that were chosen for HDI (Human Disturbance Index) are tree cut, tree stumps, human trail, forest fire and litter. Forest fire is found to be the most effective index that affects the habitat & occupancy pattern of Himalayan Musk deer.

References

Khadka KK, and James DA 2016. Habitat selection by endangered Himalayan musk deer (*Moschus leucogaster*) and impacts of livestock grazing in Nepal Himalaya: Implications for conservation. *Journal for Nature Conservation* **31**: 38–42.

Maksimova DA, Seryodkin IV and Zaitsev VA 2015. Musk Deer (*Moschus moschiferus*) population density based on pellet group count method in Sikhote-Alin. *Achievements in the Life Sciences* **9**(1): 57–60.

4.3/T_4-10

Screening of Different Cultivars of Turmeric on the basis of Curcumin under Konkan Condition

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Keywords: Turmeric, curcumin, essential oil, benefit, cost

1. Introduction

Turmeric (*Curcuma longa* L.) is one of the important spice crop of Maharashtra known as golden spice. Curcumin is the worldwide demanding potent compound present in turmeric having several medicinal and pharmaceutical uses. The demand of turmeric in the international market on the basis of curcumin content is increasing day by day. In Maharashtra major share is of Salem variety under turmeric cultivation. However, the curcumin content of this variety is ranging from 3.5 to 4.5 %. The extraction of the curcumin from the Salem variety is uneconomical as it is having less curcumin as compared to the other improved varieties. Hence, there is demand from turmeric processing industries to screen the high curcumin content variety suitable for cultivation in the Maharashtra so that the traditional Salem variety can be replaced by the improved variety.

2. Materials and methods:

The commercial improved varieties having highest curcumin released by different organizations in turmeric are location specific (Maurya et al 2018). The curcumin content in these varieties is governed by G x E interaction. Therefore, eight high curcumin varieties released by different organizations in India are screened to find out the suitable cultivar having highest curcumin content for Konkan region. The present research was carried at Post Graduate institute of Post Harvest Technology and Management of MAPSF, Killa, Roha Maharashtra in Randomized Block Design (RBD).

Table 1. Curcumin yield and essential oil of turmeric cultivars grown in Konkan Condition

Treatments	Curcumin yield (kg ha^{-1})	Duration (days)	Essential Oil (%)	Curcumin (%)	B:C Ratio
T_1: Roma	232.04	246.0	4.1	4.88	1.92
T_2: Pragati	286.35	192.0	5.9	5.55	2.54
T_3: Waigaon	190.01	181.0	4.9	4.90	1.68
T_4: Megha-1	201.88	257.0	4.5	4.19	1.67
T_5: BSR-2	238.07	240.0	3.7	4.07	1.97
T_6: Pratibha	267.65	221.0	5.8	5.00	2.22
T_7: Salem	296.77	264.0	3.7	4.63	2.45
T_8: Phule Swarupa	246.18	243.0	4.4	5.10	2.04
S. E.$\pm$	21.43	3.81	0.13	0.07	
C. D. 5%	65.00	11.54	0.40	0.21	

3. Results and discussion

Among the different eight cultivars studied at konkan condition, from the pooled data of three years the cultivar 'Salem' produced highest mean curcumin yield (296.77 kg/ha) which was at par with cultivar 'Pragati' (286.35 kg/ha). The cv. Pragati is short duration (192 days) as compared to Salem (264 days). The highest essential oil percentage was recorded in Pragati (5.9 %) which was at par with Prathibha (5.8%). The maximum B:C ratio was recorded by Pragati (2.54) followed by Salem (2.45) while lowest B:C ratio was recorded by Megha-1 (1.67). The soils of the Konkan region are rich in the organic carbon which plays an active role in the biosynthesis of the curcumin in plant. Hence, it is recommended for turmeric processors to use 'Pragati' early variety of turmeric having higher curcumin and essential oil yield for Konkan region.

The similar results were noticed by Salimath et al (2014) in studies evaluation of turmeric cultivars for growth and yield in southern dry zone of Karnataka

References

Salimath S, Venkatesha J, Kulkarni S and Shetty RG 2014. Evaluation of turmeric (*Curcuma longa* L.) cultivars for growth and yield in southern dry zone of Karnataka. *Advance Research Journal of Crop Improvement* **5**(2): 162-65.

Maurya Rohit, Pandey VP, Yadav Sandeep, Yadav Shubham and Verma Rahul Kumar 2018. Evaluation of Turmeric (*Curcuma longa* L.) Genotypes for growth, yield and quality traits under Northern plains of India. *Int. J. Curr. Microbiol. App. Sci.* **7**(05): 2472-2477.

4.4/T_4-11

Preparation of *Aloe vera* Powder by Different Drying Methods

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Keywords: *Aloe vera,* drying methods, powder, shelf life, TSS

1. Introduction

Aloe vera is a medicinal plant and due to its extensive medicinal, nutraceutical and other uses there is a great demand in the market across the globe. Drying is one of the best methods for preserving the food materials. It increases the shelf life by decreasing the water activity in the product which inhibits the growth of microorganisms while decreasing spoilage reactions. Hence, the present study was undertaken to prepare *A. vera* powder by different drying methods.

2. Material and methods

The present research was carried at PG institute of Post Harvest Technology and Management of MAPSF, Killa, Roha Maharashtra to find out suitable drying method and to standardize process for preparation of *A. vera* powder which evaluates physico –chemical properties and storage stability of powder. The powder was prepared from convective tray drying method at 50ºC. Standardized powder was packed in polyethylene bags. This product was kept at room temperature for further storage studies after packaging. Powder quality parameters were analyzed at 0, 30, 60 and 90 days storage periods.

3. Results and discussion

During the storage period, L* value, b* value of colour, total ash, titrable acidity, fat, protein, fiber and solubility decreased with increase in storage period. The a* value of colour, TSS, moisture content, pH values were increased with increase in storage period. All the parameters significantly influenced by packaging material and storage time.

In the process of preparation of *A. vera* powder by different drying methods, convective tray drying method gave significant results. It was observed that powder had particle size of 37 micron, initial moisture 98.70 %, final moisture 3.70 %, drying time 17.44 hours, rate of drying 5.445, colour value for L*, a* and b* was 39.18, 4.78 and 32.48, respectively. These results are in confirmative with Ramchandra and Srinivasa (2011). In chemical parameters total ash 14.08 %, titrable acidity 0.47 %, fat 2.16 %, protein 4.18%, fiber 16.54 %, pH 4.31, TSS 4.50ºBrix, moisture content 3.85 % and solubility 3.16 minutes, respectively. Similar results were obtained by Preetider and Amrit, (2017)

From overall observations it was concluded that convective drying is suitable method for preparation of *A. vera* powder followed by microwave drying, polytunnel drying and Sun drying. Convective tray drying at 50°C was suitable temperature for preparation of *A. vera* powder and it was stored for 90 days at room temperature without affecting its quality and also found suitable for human consumption.

References

Preetider and Amrit 2017. Optimization of spray drying conditions for production of Aloe vera powder. *Chem Sci. Rev Lett.* **6**(21): 525-532.

Ramachandra CT and Srinivasa Rao P 2011. Shelf- life and colour change kinetics of Aloe vera gel powder under accelerated storage in three different packaging materials. *J. Food Sci. Technol.* **50** (4):747 – 754.

4.5/T_4-21

Effect of Girth on Recovery of Katha in Traditional Method of Extraction

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Keywords: *Acacia catechu*, heartwood, katha, cutch, girth class

1. Introduction

Khair (*Acacia catechu* Willd.) is a deciduous tree containing dark red heartwood inside the sapwood belongs to the family Fabaceae. It yields mainly two products katha and cutch which have many medicinal benefits and industrial uses. Katha is an indispensible ingredient of *pan* preparations in India.

2. Material and methods

The present study was carried out in Ratnagiri district of Konkan region of Maharashtra India, to assess the katha yield using traditional method of extraction. The heartwood of Khair was divided in different girth classes *viz.* upto 30 cm, 30 to 40 cm and 40 to 50 cm. The extraction of katha was done by chipping and boiling of heartwood.

3. Results and discussion

The results revealed that the recovery percentage of katha ranged from 5.06% to 6.68% with overall recovery was 5.97 per cent. The maximum recovery was reported in the 40 to 50 cm girth class while minimum in girth class upto 30 cm. Range of the katha recovery reported in this study is in accordance with the finding of Fernandez (1894) and found more than that obtained by Mathur (1961). Result also revealed that the katha recovery from Khair heartwood vary with respect to girth of heartwood. The yield of katha is govern by various factors like weight of heartwood, location, forest type, annual rainfall, chip thickness, age, disc position of heartwood, site quality, *etc*.

References

Mathur CM 1961. Recovery percentage of katha and heartwood weight tables of *Acacia catechu*. *Indian Forester* **87**(10): 609-610

Fernandez EE 1894. Yield of katha. Iron making by means of gas-furnaces: 258-259

4.6/T_4-25

Effect of Heat Treatment on Bending Strength of *Acrocarpus fraxinifolius* Wight & Arn.

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Keywords: *Acrocarpus fraxinifolius,* wood, bending strength, heat treatment

1. Introduction

Heat treatment of wood involves treatment of wood at high temperature in the absence of oxygen that affects the wood properties by modifying their constituents and altering the chemical composition of wood cells by decomposing their cell wall components. Bending strength is an important parameter in the utilization of the wood, which is the measure of ability of wood to resist the failure.

2. Material and Methods

The property of *Acrocarpus fraxinifolius* wood was determined according to the procedure prescribed by Indian Standard IS: 1708 in Universal Testing Machine (Model: UTN-10) after giving the heat treatment at four different temperatures (80, 120, 160, 200 °C) for 2, 4 and 6 hours durations. The experiment was laid in CRD factorial and three replicates for each treatment were taken. The standard size of the specimens taken for this test was 300×20×20 mm.

3. Results and discussion

Bending strength in *A. fraxinifolius* increased in the beginning of the heat treatment and decreased afterwards with increase in treatment temperature while duration has no significant effects. The maximum bending strength (0.010 kN/mm^2) was noticed in control and was at par with 0.009 kN/mm^2 at 80°C while; minimum strength (0.007 kN/mm^2) was observed at 200°C and was at par with 0.008 kN/mm^2 at 120°C and 160°C (table 1). Among the durations, non-significant results were found. The interactions of temperatures and durations were also found to be non-significant and the values ranged between 0.007 to 0.010 kN/mm^2. The degradation of hemicelluloses during heat treatments is mainly responsible for the decrease in bending strength.

Table 1. Bending strength (kN/mm^2) of thermally modified *A. fraxinifolius* wood

Duration(h) / Temperature (°C)	2h	4h	6h	Mean
80°C	0.010	0.009	0.008	0.009
120°C	0.008	0.009	0.008	0.008
160°C	0.008	0.009	0.008	0.008
200°C	0.007	0.007	0.008	0.007
Control	0.010	0.010	0.010	0.010
Mean	0.009	0.009	0.009	
$CD_{0.05}$				
Temperature (T)	0.002			
Duration (D)	NS			
Temperature×Duration (T×D)	NS			

4.7/T_4-27

Factors Affecting Oleoresin Yield in *Pinus roxburghii* Sargent

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Keywords: *Pinus roxburghii*, oleoresin, terpenes, borehole, drilling

1. Introduction

Oleoresin from *Pinus roxburghii* Sargent, a complex mixture of volatile and non-volatile terpenes, is an important non-wood forest product, mainly tapped in the States of Himachal Pradesh and Uttarakhand. In the present work studies have been conducted on the effect of borehole height, diameter class and drilling month on oleoresin yield aiming at the improvement, standardization and increased oleoresin yield.

2. Material and methods

Studies were conducted in natural stand of *P. roxburghii* trees, at YSP, UHF Nauni, Solan, India. Oleoresin tapping was done with borehole method standardized by university. Trees were selected, marked and classified into four diameter classes *viz.*, 30-40, 40-50, 50-60 and >60 cm. Six boreholes at different months *viz.*, March, April, May, June, August and September were drilled and yield was recorded. Three borehole heights *viz.*, 50, 100 and 150 cm were studied for yield. Each replication comprised of four trees.

3. Results and discussion

Highest yield of oleoresin 3,900.89 g/season was recorded at150 cm borehole height. Maximum value (665.17 g/hole/tree) in diameter class >60 cm was observed for yield as affected by the borehole height and diameter. Different treatments showed maximum yield of 650.15 g/hole at 150 cm. Interaction between height and diameter classes also showed significant effect on yield. Oleoresin yield as affected by borehole height and month of boreholes drilled recorded highest yield (628.47 g/hole/tree) and for different months, the highest yield of 897.34 g/hole/tree was observed in June. Results of the work shows positive effect of diameter class, borehole height and drilling month on oleoresin yield. The studies carried out by various scientists revealed that diameter has a marked effect on the output of oleoresin in pines.

Figure 1. Boreholes at different heights *viz.*, 50, 100 and 150 cm in *P. roxburghii*

References

Aaltonen H, Pumpanen J, Pihlatie M, Hakola H, HellenH and Kulmala L 2011. Boreal pine forest floor biogenic volatile organic compound emissions peak in early summer and autumn. *Agricultural and Forest Meteorology* **151**: 682-91.

Lekha C and Sharma K R 2005. Borehole method of oleoresin tapping in chirpine (*Pinus roxburghii* Sargent). *Forest Chemical Review* **115**(3):11-17.

$4.8/T_4$-30

An Ethnobotanical study on Traditional Knowledge of Medicinal Plants used by Villagers Dependent on Khordha Forest Division part of Eastern Ghats, India

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Keywords: Ethnobotany, Medicinal plants, ailments, health care, Eastern Ghats

1. Introduction

Traditional medicinal plant knowledge is an important part of primary health care system of villagers dwelling in remote places those depends upon forest resources (Macia et al 2004). The Easten Ghats harbours a rich plant wealth and contributes significantly to endemicity of Indian flora (Reddy et al 2011). Ethnobotanical studies hold a major importance to revel the people's knowledge and dependency on local flora which have practical importance from the prospective drug development (Suntar 2020). The present study aimed at documenting traditional knowledge and practices about the medicinal plants in use by the villagers of the study site.

2. Material and methods

Nine villages (e.g. Baladibari, Phasipada, Katurikata, Podakhai, Nakulapalli, Gambharisihali, Damiabarabara, Balikania, Mayujhara) were selected for the survey which lies within a maximum 5 km periphery of the divisional forest. It is aerially about 40 km away from Chilika lake that is attached to Bay of Bengal, Odisha. We have interviewed 84 informants (31 female and 53 male) ranging between 29 and 86 age selected randomly. Information was collected through open and semi-structured interviews from local people. Sixteen informants of these informants were traditional healers (THs). Information on local name, plant part used, mode of use, habit, habitats was gathered and ailments treated by the informants was arranged according to International Classification of Primary Care (ICPC)-2. Use Reports (UR) was used in analysing primary data. The use value (UV) was calculated for each plant species (Kichu et al 2014). Informant Consensus Factor (F_{ic}) was calculated to find the homogeneity of the collected information about a plant used for a specific ailment (Trotter and Logan, 1986).

3. Results and discussion

Documentation of indigenous ethnomedicinal knowledge: A total of 182 species of medicinally important plants as reported from the informants were recorded belonging to 65 families and 108 genera. The dominant family from these plant records were Asteraceae (15.38%), Lamiaceae (12.08%), Fabaceae (9.89%), Malvaceae (7.69%), Euphorbiaceae (6.04%), Rosaceae (5.49%), Moraceae (4.94%), Cucurbitaceae (4.94%). It was found that herbs (39.56%), shrubs (30.21%), climbers (17.03%), trees (13.18%) were the most frequently used life -forms. Plant part used in making recipe for treating ailments revealed that leaves (33.51%), roots (26.92%), fruit (20.87%), whole plant (8.24%). The drugs were administered either orally (72.6%) or applied externally (27.4%). Frequency of citations (FC) was calculated for each species which corresponds to an indicative value for the cultural significance of the medicinal plant. Total 1288 use-reports (UR) were cited. The species with highest FC were *Boerhavia diffusa* (38 FC), *Indigofera tinctorea* (34 FC), *Ficus racemose* (33 FC), *Hemidesmus indicus* (27 FC), *Justicia adhatoda* (26 FC). *Informant consensus factor (F_{IC})*: A total of 65 disorders grouped into 13 ailment categories based on ICPC-2 classification. The values of the Informant Consensus Factor (F_{IC}) for these ailment categories ranged between 0.32 (Female Genital), Urological (0.86).

Table 1. Informant consensus factor for various reported ailment categories

ICPC-2 Categories (code)	Ailments	nur	nt	F_{IC}
Urological (URO-U)	Kidney problems, renal disorders, urinary problems, urolithiasis	175	32	0.86
Digestive (GAS-I)	Acidity, bile complaints, cholera, constipation, diarrhoea, dysentery, gastric problems, hepatitis, intestinal worms, Indigestion, jaundice, liver ailments, mouth sore, stomachache, toothache, ulcers, vomiting *etc*.	357	72	0.82
Neurological (NERN)	Headache, heart problems, mental disorders, migraine	45	12	0.82
Cardiovascular (CAR–K)	Bleeding, blood pressure, heart problems, piles	75	18	0.81
Endocrine/Metabolic and Nutritional problems (MET–T)	Diabetes	84	25	0.78
Respiratory (RES-R)	Asthma, bronchitis, cough and cold, whooping cough	141	42	0.73
Musculoskeletal (SKE–L)	Arthritis, body-ache, bone fracture, rheumatic pains	109	30	0.71
Skin (DER–S)	Boils, burns, cuts and wounds, eczema, itching, leprosy, leucoderma, snakebite, sores	179	66	0.70
Pregnancy (PRE–W)	Delivery, Infant teeth	6	3	0.67
General and unspecified (OTH-A)	Aphrodisiac, fever, malaria, pneumonia, tonic	89	43	0.63
Eye (EYE–F)	Conjunctivitis, nightblindness	15	6	0.60
Female Genitals (GYN–X)	Abortion, Gonorrhea, leucorrhoea	10	5	0.32

Abbreviation used – ICPC, International Classification of primary Care; nur, number of use reports; nt, number of taxa, and F_{IC} , Informant Consensus Factor.

References

Kichu M, Malewska T, Akter K, Imchen I, Harrington D, Kohen J, Vemulpad, S R and Jamie, J F 2015. An ethnobotanical study of medicinal plants of Chungtia village, Nagaland, India. *Journal of Ethnopharmacology* **166:** 5-17

Macía MJ, García, E and Vidaurre PJ 2005. An ethnobotanical survey of medicinal plants commercialized in the markets of La Paz and El Alto, Bolivia. *Journal of ethnopharmacology* **97**(2): 337-350.

Reddy S, Babar S, Amarnath G and Pattanaik, C 2011. Structure and floristic composition of tree stand in tropical forest in the Eastern Ghats of northern Andhra Pradesh, India. *Journal of forestry research* **22**(4): 491-500.

Süntar, I 2020. Importance of ethnopharmacological studies in drug discovery: role of medicinal plants. *Phytochemistry Reviews* **19**(5): 1199-1209.

Trotter RT and Logan MH 1986. Informant consensus: a new approach for identifying potentially effective medicinal plants. pp 91–112 In: Etkin NL. (Ed.). *Plants in Indigenous Medicine and Diet, Behavioural Approaches*. Redgrave Publishing Company, Bredford Hills, New York.

4.9/T_4-41

Nutritive Value of *Melia dubia* Cav. Drupe pulp and its Feeding Effect on Surti Goat (*Capra aegagrus hircus* L.) Kids

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1. Introduction

India is an agriculture dominated country having largest livestock population in the world. In India, there is a huge annual shortage of concentrates, green fodders, and dry roughages for animal feeds. These estimates do not include feed resources from shrubs and tree leaves and fruits. There are a number of lesser-known and under-utilized plants that adapted to local, harsh conditions and have tremendous potential as livestock feed. *Melia dubia* Cav. is one such species, drupes of which may be utilized as top feed. Goats and cattle browse on *M. dubia* drupes, however, scientific and systematic information about nutritive value of drupe pulp as a feed resource is not attempted along with its feeding effect either on cattle or small ruminants.

2. Material and method

This study was carried out at the institutional research farm of the College of Forestry, Navsari Agricultural University, Navsari, Gujarat in 2017–2018. Variation in drupe morphometric, proximate principles, total phenols and other volatile phytochemicals was carried out among 9 provenances. Feeding experiment (for 90 days) with basal feed replaced by *M. dubia* drupe pulp @ 20% and 40% along with basal ration alone was conducted on Surti Goat kids in cages. Data were analyzed as per CRD.

3. Result and discussion

Drupe morpho-metric and biomass attributes, proximate principles, mineral matter and total phenols differed significantly among the studied populations. Average drupe length and width was found 25.60 and 20.92 mm, respectively. Whereas, average drupe fresh weight, pulp fresh weight, pulp dry weight, stone weight was 678.93, 476.45, 166.10 and 202.48 g/100 drupes, respectively. Dry matter and moisture contents were 35.28 and 64.72%, respectively. Similarly, an average crude fibre, crude protein, ether extract, total ash and nitrogen free extract content of 9.97, 6.07, 2.41, 7.10 and 74.46%, respectively was found in drupe pulp of different populations. Overall average Ca, Mg, P and K content of 0.50, 0.16, 0.14 and 2.01%, respectively was recorded in 9 provenances. An average 0.48% total phenols were recorded which were within the permissible limit. *M. dubia* pulp could be categorized as good feed resource with low in fibre, but rich in energy and minerals. Total mixed rations (TMRs) replaced by *M. dubia* drupe pulp (T_1 - Basal feed; T_2 - 20% basal feed replaced by *M. dubia* drupe pulp; T_3 - 40% basal feed replaced by *M. dubia* drupe pulp) did not have any significant effect on body weight of kids and dry matter intake by the kids of all groups. On the other hand, there was no significant effect of TMRs as well as period on growth rate and feed conversion ratio of Surti goat kids. Inclusion of *M. dubia* drupe pulp in different TMRs of Surti goat kids reduced the cost of feeding with maximum at 40% replacement (Rs. 1012.33/group (8 kids) over the basal feed (control group). The proximate principles, mineral matter and total phenols content found in *M. dubia* drupe pulp are in permissible limits and fall within the range found in leaves, twigs and pods/fruits of most commonly used fodder trees and shrubs throughout the world. Even it has better feed parameters compared to most of the forage grasses and fodder species. Further, corroboration with feed and fodder standards, the pulp of *M. dubia* can be included in mineral, fat, carbohydrate and energy rich feed source category. Thus, the present investigation divulged that *M. dubia* drupe is a good alternative/agro-industry by-product as a feed source for small ruminants.

4.10/T_4-42

Trees as Feed and Fodder Resources: Potential and Prospects for Small Ruminants

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Keywords: Fodder, tree, browsing, ruminants, alternate feed

1. Introduction

India caters to approximately 20% of the world's livestock population and about 17.50% of the human population on just 2.30% of the world's land area. Escalating human and animal population are fighting tooth and nail for land resources for food and fodder production. Cultivated fodders occupy only 4.00% of the entire cultivable land in the country. Presently, the country faces a net shortfall of 35.60% green fodder, 10.50% dry crop leftovers, and 44.00% concentrate feed ingredients. The option for increasing land area under fodder cultivation is very limited. Leaves and pods of fodder trees or shrubs are known as "Top Feeds" which serve as fodder for small ruminants. These trees and shrubs provide nutrients to the livestock virtually free of cost during lean period when surface grass is grazed away and other type of fodder are not available.

2. Materials and methods

The literature pertaining to trees as feed and fodder source were collected from the internet and University Library. The status of use of trees as fodder was interpreted for different regions of country being used commonly. Proximate, mineral matter and other phytochemical compositions was compared among the available studies. To make the small ruminant, rearing sole or integrated manners, productive and economical, it is important to explore the quality and extent of tree feed and fodder resources.

3. Result and discussion

Sufficient evidence from research has shown that improved animal production can be obtained by

Table 1. Overview of proximate and mineral matter content of commonly browse tree species

Tree Species	Crude Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract	Total Ash	P	Ca	Neutral Detergent Fiber
Sesbania grandiflora	33.4	-	-	-	-	0.34	-	-
Sesbania sesban	25.6	6.2	21.7	45.2	10.8	-	-	32.2
Gliricidia sepium	22.3	4.2	19.70		7.10	2.3	11.9	49.10
Grewia oppositifolia	22.5	4.4	34.6	-	9.6	-	-	57.9
Leucaena leucophala	23.33	1.92	12.83	55.77	6.15	-	-	-
Melia azedarach	29.25	-	15.47	-	8.78	-	-	21.81
Moringa oleifera	25.0	10.6	7.9	-	8.40	-	-	-
Morus alba	17.49	2.61	12.41	56.04	11.45	-	-	24.4
Morus rubra	25.89	-	15.67	-	15.74	-	-	22.8
Pongamia pinnata	19.36	-	30.85	-	9.19	-	-	52.59
Prosopis chilensis	18.30	1.82	21.79	39.94	18.15	1.20	4.86	64.18
Acacia Catechu	18.2	-	34.32	-	-	-	-	53.62
Acacia nilotica	16.9	5.5	23.9	-	6.6	-	-	33.1
Ailanthus excelsa	19.87	3.53	12.82	51.81	11.97	-	2.11	-
Albizia procera	19.0	3.58	29.41	-	8.40	-	-	-
Azadirachta indica	17.04	2.74	29.41	46.27	8.44	-	-	-

Antony and Lal (2014)

incorporating tree and shrub as fodder for small ruminants. Reynolds and Cobbina (1992) found that sheep and goats fed with *Leucaena leucocephala* and *Gliricidia sepium* foliage increased the overall productivity. In another study they found that supplementary browse resulted in increased rate of weight gain in growing and fattening sheep. Rangnekar (1991) found that many tree leaves, flowers and pods are useful in improving milk production, milk fat, body condition and induction of oestrus. Leng *et al*. (1991) revealed that supplements of *Enterolobium cyclocarpum* leaves significantly increased the rate of body weight gain (24%) and wool growth (27%) in sheep.

Table 2. Comparative effect of tree fodder feeding on performance of sheep and goat

Basal feed	Fodder supplement	Response	Livestock species
Rice straw	*Leucaena* (50% of ration)	Significant increase in organic matter digestibility (9%), energy intake (86%), and nitrogen retained (256%)	Sheep
Gliricidia	*Leucaena* (50% of ration)	Significant increase in digestible dry matter intake (12%) and growth rate (55%)	Goats
Guinea grass hay	*Gliricidia* (30g/kg $W^{0.75}$)	Doubling effect on digestible dry matter intake	Goats
Guinea grass hay	*Leucaena* (30g/kg $W^{0.75}$)	66% increase in digestible dry matter intake	Goats

Smith (1991)

The available literature shows that tree feed and fodder provide protein rich resource during lean period. The studies show that the tree fodder either sole fed or in combination with grasses/concentrates result in increased milk and meat production in small ruminants. Inclusion of tree fodder in ration of small ruminants increase the feed intake, digestibility and its efficiency, thus fodder trees/shrubs act as productive potential source for small ruminants.

References

Antony JR and Lal SB 2014. Agroforestry theory and practices, Scientific publishers, Jodhpur, India. Pp 602-612.

Leng RA, Bird SH, Klieve A, Choo BS, Ball FM, Asefa G, Brumby P, Mudgal VD, Chaudhry UB, Haryono SU and Hendratno N 1991. The potential for tree forage supplements to manipulate rumen protozoa to enhance protein to energy ratios in ruminants fed on poor quality forages. *In:* Legume trees and other fodder trees as protein sources for livestock, (MARDI), Malaysia.

Rangnekar DV 1991. Feeding systems based on the traditional use of trees for feeding livestock, *In:* Legume trees and other fodder trees as protein sources for livestock, (MARDI), Malaysia.

Reynolds L and Cobbina J 1992. Contributions of leguminous trees to livestock nutrition, Unit 4: The Integration of Livestock Production in Alley Farming, The AFNETA alley farming training manual - Volume 1: Core course In alley farming, Alley Farming Network for Tropical Africa – Ibadan.

Smith OB 1991. Fodder trees and shrubs in range and farming systems in tropical humid Africa, *In:* Legume trees and other fodder trees as protein sources for livestock, MARDI, Malaysia.

4.11/T_4-49

Effectiveness of *Pongamia pinnata* Seed Extract Against Mold Fungi

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Keywords: *Pongamia pinnata*, inhibition, mold, soxhlet, distillation

1. Introduction

Pongamia pinnata is a legumimous tree having tap root system and symbiotic relationship with nitrogen-fixing bacteria which prevents soil erosion. *P. pinnata* commonly known as Indian Beech or Karanj, belongs to the family Fabaceae. Its seeds have antifungal and antibacterial properties. Mold fungi causes significant problems in building and degrades its aesthetic value. Fungi colonize in the wood and degrade cell wall components like cellulose, hemicellulose, lignin. The hyphae of fungi penetrate the wood which can degrade the call wall constituents (Chandra 2009).

2. Material and methods

The present investigations were carried out in Wood Preservation Discipline, Forest Research Institute, Dehradun in which *P. pinnata* seeds extract used to check the inhibition of mold fungi on PDA media. *P. pinnata* seeds were crushed in crushing machine and extract was extracted through soxhlet extraction method. Desirable amount of crushed Karanj seed powder in a thimble placed inside soxhlet chamber and extraction was carried out using petroleum ether as a solvent. After extraction, distillation process was done to remove excess solvent from the extract. The extract obtained was yellowish brown in colour. The petri plates containing PDA media were treated with seed extract and inoculated with *Aspergillus niger* and *Penicillium* spp. The higher yield of seed extract can be achieved in the temperature range of 60–70^{0}C. Potato Dextrose Rose Bengal Agar with antibacterial properties, were used in an experiment to prevent the further infestation of mold by other fungi or microorganisms in petri plates kept inside the B.O.D incubator at 25±2 ^{0}C temperature and 75% R.H. The growth on media after 14 days were calculated.

3. Results and discussion

The results showed that *A. niger* has more inhibition than *Penicillium* spp. on treated media. The both mold fungi's showed considerable growth on petri plates containing media. But, it showed some negative impact on the growth of mold. The rate of growth of *A. niger* and *Penicillium* spp. *w*ere delayed or slowed down. The fungal growth in the form of colonies have been shown by *Penicillium* species.

Reference

Chandra A, Harsh NSK, Tripathi S and Lepcha STS 2009. Preliminary screening of neem seed oil against *Schizophyllum commune*- A bamboo degrading white rot fungus. *Indian Forester* **135**(11): 1511-14.

4.12/T_4-55

Buchnania lanzan Spreng (Chironji): An Undervalued Tree for more Bang for Tribal Buck of South-Eastern Rajasthan

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1. Introduction

Buchanania lanzan Spreng (Chironji), (Anacardiaceae family), an economically important endangered and a non-nationalized minor forest produce, widely distributed in the forests of the Central regions of India, is an excellent multipurpose tree of agro-forestry and social forestry. Its multifarious uses and significant resistance have proven to be a socio-economic boon to the tribal community in central states including South-Eastern Rajasthan.

2. Material and methods

Fruits were collected in the month of April from Shahabad Forest area of Baran district in Rajasthan. Proximate analysis of fruits was done on physical and biochemical parameters. Shelf life was recorded by the number of days fruit showed 10 per cent PLW. Total soluble solids, titratable acidity, ascorbic acid and sugars were determined by hand refractometer, titration method using phenolphthalein as an indicator, volumetric method by using 2, 6-dicholorophenol-indophenol dye and by reduction method using Methylene blue indicator, respectively.

3. Results and discussion

Proximate composition of the *B. lanzan* shows the nutritional potential of the wild fruit. Physical parameters *viz.* fruit weight (1.24±0.16g), peel weight (0.17±0.09 g), pulp weight (0.62±0.15 g), seed weight (0.44±0.04g), pulp percentage (49.76±7.8) and shelf life for 2 days at room temperature and 6 days in refrigerator evident that the fruits have about 50 percent pulp of the total fruit weight which is economically feasible and give satisfactory amount of the edible portion. Biochemical parameters *viz.* TSS (26±2.94^0 Brix), ascorbic acid (120±23 mg/100 g), titratable acidity (1.3±0.2%), total sugar (28±2.6%) and reducing sugar (20±2.3%) were found significantly compatiblewith cultivated counterparts as mango and guava which can play a vital role in ensuring food security and poverty reductionof rural and tribal communities and sustaining agricultural diversification.

4.13/T_4-63

Present Scenario of Gum Tapping and its Utilization in India

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Keywords: Gum, tapping, NTFP, trade, value chain

1. Introduction

Gums are the major NTFPs of Indian Forests. Gums have highly significant role in food, health, cultural purposes, paper, textiles, cosmetics and medicinal industries. Demand of such products have increased significantly. Yet there is a tendency to underestimate their role because they are poorly represented in international statistics mostly their use and trades are confined to the informal sector.

2. Material and methods

Literature on the Production, processing and trade, policy implications, the practices adopted by different states for extraction of gum, methodology for procurement. Search was made for cost of collection to calculate production of NWFPs in different states, Mechanism for marketing of Minor Forest Produce through Minimum Support Price and development of Value Chain for MFP. All the collected information obtained through research papers and articles, various reports was formulated and analysed for better organization of gum producing states to meet the demand through better organization of their local/ regional/ national commercial channels from production to export. The published information had been based on secondary observations including recent data of 2017-21.

3. Result and discussion

It is been observed that modern practices are needed to increase the quantity of gum production with quality improvement. Unlike synthetic gum, natural gum has not been commercially successful due to the unavailability of proper technical knowledge on the extraction and tapping technique. However, it is a concerning matter that the traditional knowledge of tapping, processing, and other practice of using natural gum has reduced to a great extent among the ethnic people due to the easy availability of cheap synthetic gums. It has been seen that the classical knowledge of plant gum is now very much confined among the surviving older people only and few practitioners in the local tribal communities of forest patches India. Unfortunately, serious attempts have not been made to proper documentation and preservation of this natural treasure of traditional knowledge of natural gum and its tapping associated with the indigenous people. Again, due to the least focus on conservation strategy also causing a steep depletion of this valuable resource. Otherwise, the vital information on the utilization of natural resources around us will be lost.

Reference

Yogi RK, Kumar Nirmal and Sharma KK 2021. Lac, Plant Resins and Gums Statistics 2019: At a Glance. ICAR-Indian Institute of Natural Resins and Gums, Ranchi (Jharkhand), India. Bulletin (Technical) No. 3/2021. 01-82 pp.

4.14/T_4-64

Effect of Different Seed Treatments and Media on Growth and Biomass of Indian Cheese Maker- *Withania coagulans* (Stocks) Dunal

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Keywords: *Withania coagulans*, seed treatment, media, growth, biomass

1. Introduction

India is rich in medicinal and aromatic plants covering an extensive area with different environmental conditions. *W. coagulans* is distributed in the East of the Mediterranean region extending to South Asia *i.e*., Iran, Afghanistan, Pakistan (Sind and Baluchistan), Nepal and India, up to 1700 m. In India, it is found in (North-West India) Himachal Pradesh, Punjab, Uttarakhand and Rajasthan. In Rajasthan it is sporadically distributed in Barmer, Jaisalmer and Jodhpur districts of Western Rajasthan desert and it is not common, categorized as "vulnerable species" (Pandey et al 2012).

2. Material and methods

The experiment was conducted at the Model Nursery on Medicinal and Aromatic Plants, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat in 2019-20. The experiment was conducted in completely randomized design with factorial concept, including twenty treatment combinations comprising of four levels of seed treatments with GA3 (0, 50, 100, 150 ppm) and five levels of different growing media. Data were analysed as per standard statistical procedure using completely randomized design with factorial concept (FCRD).

3. Result and discussion

Among various concentrations of GA3 as pre-soaking treatment, 150 ppm GA3 (S) showed significantly better results for germination, growth, biomass and alkaloid content in *W. coagulans*. Similarly, among growing media, red soil (M1) recorded maximum germination percentage, collar diameter, number of branches per plant, number of leaves per plant, total leaf area, length of the main root, thickness of main root, root dry biomass, shoot dry biomass, fresh weight of plant, dry weight of plant, survival percentage of the plant and total alkaloid content of plant. Overall, the result indicated that that pre-sowing seed treatment with GA3 -150 ppm for 24 hrs and subsequently sowing treated seeds in M1 media comprising of red soil (control) can enhance growth and alkaloid content. Interaction effect between pre -sowing seed treatments and different growing media was found non -significant in all case except number of branches at 30 DAS and total alkaloid content. In conclusion, germination and growth of Indian cheese maker – *W. coagulans* can be enhanced by sowing the seed pre-soaked in the 150 ppm GA3 for 24 hours and placing it in the red soil. Positive effect of pre-treatment on alkaloid content suggests the potential of enhancing productivity of *W. coagulans* in net house.

Reference

Pandey RP, Meena SL, Padhye PM and Singhadiya MK 2012. A review of depleting plant recourses, their present status and conservation in Rajasthan, India. *Biological Forum* **4**(1): 213-230.

4.15/T_4-66

Variation in Oil Yield and Composition of Two *Eucalyptus* species

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Keywords: *Eucalyptus tereticornis, E. camaldulensis*, oil yield, oil composition

1. Introduction

One of important genera of Myrtaceae is *Eucalyptus*, which is a large genus of evergreen trees containing about 900 species, although plants are native to Australia, they have been successfully introduced worldwide. However, *Eucalyptus* is extensively planted for pulp, plywood and solid wood production, but its leaf aromatic oil has astounding widespread utility. Variation in oil yield & composition of different species is lesser known.

2. Material and methods

Fresh leaves of *E. tereticornis* and *E. camaldulensis* were collected. Volatile oil was obtained from freshly collected leaves by hydro- distillation using Clevenger apparatus. The extracted oil collected after hydro-distillation contain small amount of water which was removed by adding petroleum ether and separated through separating funnel and oil yield was quantified. The chemical composition of the volatile oil was analysed by GC/MS on a mass spectrometer fitted with a flame ionization detector (FID) and coupled with GC 2010 gas chromatograph (Emara and Shalaby 2011).

3. Results and discussion

Maximum oil was obtained in *E. tereticornis* (0.75%) than *E. camaldulensis* (0.67%). Gas chromatography and mass spectrometry (GC & MS) analysis revealed that maximum components (37) were found in *E. camaldulensis* and minimum (29) in *E. tereticornis*, whereas major oil component cineole was maximum (82.37%) in *E. tereticornis* and in *E. camaldulensis* it was 73.77%. But, *E. camaldulensis* showed maximum concentration of other minor components like α- Pinene (18.47%), 2-Isopropenyl (1.22%) and *E. tereticornis* α- Pinene (11.67%), 2-Isopropenyl (0.47%). Both species showed variation in growth parameters like volume and pest tolerance in which *E. tereticornis* found superior than *E. camaldulensis.* By this study we conclude that variation in both species due to environment and genetic makeup so by utilising superior genotypic species we can use it for commercial purpose.

Table 1. Yield percentage of essential oil of *Eucalyptus camaldulensis* and *Eucalyptus tereticornis*

Sr. No.	Species	Oil yield (%)	No of chemical components (GC & MS)	Cineole (%)
1	*Eucalyptus tereticornis*	0.75	29	82.37
2	*Eucalyptus camaldulensis*	0.67	37	73.77
	CD (0.01)	0.09		

Reference

Emara KS and Shalaby AE 2011. Seasonal variation of fixed and volatile oil percentage of four *Eucalyptus* spp. related to lamina anatomy. *African Journal of Plant Science* **5**(6): 353-359.

4.16/T_4-72

Analysis of Physical and Chemical Properties of Coco-Peat and Bamboo Powder

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Keywords: Coco peat, physical properties, bamboo

1. Introduction

Novel applications for bamboo are currently being explored. It is also observed that, bamboo has been employed in agricultural sector as mulch, fertilizer, and livestock feed. Decomposition of coconut husks reduces C:N ratio to 30:1 and is an ideal medium for germinating seeds. Bamboo powder is a waste generated form the bamboo *agarbati* processing. There are few alternatives to utilize it to attain better value addition.

2. Materials and methods

Bamboo waste was collected from the wood workshop of College of Forestry, Dapoli. While preparing bamboo incense sticks, bamboo sawdust is produced as a by-product. The bamboo powder which was collected was already dried and mallied (small pieces). Bamboo waste was grind using the grinder to cut the fibres. Grinding makes the powder ready to use for further application. Coco-peat was collected from the local farmer, which was directly used for further analysis.

3. Result and discussion

The results of the Nitrogen, Potassium, Phosphorous, pH, EC, Carbon Percent, Water Holding Capacity and Moisture Content were presented in Table: 1. Nitrogen content in coco-peat and bamboo powder were 0.25% and 0.027%, respectively. Potassium content in Coco-peat was 0.26% and in bamboo powder was 0.029%. Phosphorous content in the coco-peat and bamboo powder were found to 0.093% and 0.10%, respectively. pH of coco-peat and bamboo powder were found to be similar *i.e.*, 7.06. EC of coco-peat and bamboo powder were 0.6 mS cm^{-1} and 0.4 $mScm^{-1}$, respectively. Carbon percent of the coco-peat was 42.27% and of bamboo powder was 55.71%. Water holding capacity observed in coco-peat was 57.34% and in bamboo powder it was 50.71%. Moisture content in coco-peat observed was 27.25%, moisture content in the bamboo powder was about 5.20%.

Table 1. Chemical analysis of coco-peat and bamboo powder

Observations	Coco-peat	Bamboo Powder	Observations	Coco-peat	Bamboo Powder
Nitrogen (ppm)	0.25	0.027	pH	7.06	7.06
Potassium (ppm)	0.2647	0.0297	EC (mS/cm)	0.6	0.4
Phosphorous (ppm)	0.0935	0.1035	Carbon Percent (%)	42.27	55.71
			Water Holding Capacity (%)	57.34	50.71
			Moisture Content (%)	27.25	5.20

References

Kalaivani K and Jawaharlal M 2019. Study on physical characterization of coco peat with different proportions of organic amendments for soilless cultivation. *Journal of Pharmacognosy and Phytochemistry* **8**(3): 2283-2286.

Takashi Fudano, Keiko Kataoka, Rihito Takisawa, Fumio Kishida, Masatoshi Toyoda, Midori Kaneko and Yutaka Shiroyama 2016.Utilization of Bamboo Powder as a Substrate for Horticulture Production. *Journal of Japanese Society of Agricultural Technology Management* **23**(2):49-60.

4.17/T_4-75

Indigenous Pattern of Collection and Utilization of NWFPS and Their Socio-Economic Sustainability for Tribal Women of Central Chhattisgarh

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Keywords: Tribal women, livelihood, NWFP, women participation, NWFP in SFM.

1. Introduction

Tribal women perform a variety of forest-based functions in theirday-to-day activity at different levels but their roles and participation tend to be poorly visible and unacknowledged. Considering women's relationships with collection, utilization and processing they perform significant role and responsibility in sustainable management of NWFPs. The gathering of everyday NWFPs particularly food, medicinal plant parts and craft materials, has always fallen into the domain of women. NWFPs have widespread promotion of these products, particularly by agencies interested in sustainable development, as tools for enhancing livelihood of women.

2. Materials and methods

For this purpose, a review study was conducted by referring 40 relevant Research papers and articles. Important findings are described.

3. Results and discussion

As compared to male, female is more compatible for collection of various plant-based medicines from locally available NWFPs which includes more significant, bamboo, tendu, cocoons and mahua and so many other types of locally availableknown minor forest produces. Providing better support, opportunity, training and documentation on their knowledge would enhance healthcare, food sources, livelihood, involvement of womenand socio-economic condition in sustainable NWFPs management.

References

Adhikary PP, Shit PK and Bhunia GS 2021. NTFPs for socioeconomic security of rural households along the forest ecotone of Paschim Medinipur forest division, India. In Forest Resources Resilience and Conflicts (pp. 239-246). Elsevier.

Patra S and Sharma S 2022. Contemporary ethnomedicinal practices among the Gond Tribe of Bilaspur District, Chhattisgarh, India. *Journal of Herbs, Spices & Medicinal Plants* **28**(1), 1-14.

4.18/T_4-79

Effect of Fertilizer Application on Growth, Biomass, Oil Content and Oil Yield in Hybrid Aromatic Tulsi Crop

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Keywords: Tulsi, aromatic, nutrient, growth, fresh biomass yield, oil content, oil yield

1. Introduction

Tulsi is an aromatic shrub in the basil family Lamiaceae that is originated in north central India and now grows native throughout the eastern world tropics. Within India, tulsi has been adopted into spiritual rituals and lifestyle practices that provide a vast array of health benefits that are just beginning to be confirmed by modern science. Tulsi is an herb, perennial, erect, branched, grow upto 1 meter high, slightly hairy and aromatic. It contains essential oil, whose main components are Linalool and methyl chavicol. Tulsi cultivation is economically profitable. The nutrient management practices involve judicious combination of inorganic fertilizers and organic manures in building soil fertility and to improve the production potential of any crop. Keeping this view, the experiment was conducted to study the "effect of fertilizer application on growth, biomass oil content and oil yield in hybrid aromatic tulsi crop".

2. Materials and methods

The field experiment was conducted for an inter-specific hybrid variety CIM-Shishir of *Ocimum* for nutrient management and laid out in randomized block design(RBD) with four replications with six treatments T_1 (control- no fertilizer), T_2 (FYM 10 T ha^{-1}), T_3 (FYM 10 T ha^{-1}) +100%NPK, T_4 (FYM 10 T ha^{-1}) + 75% NPK, T_5 (FYM 10 T ha^{-1}) +50% NPK, T_6 (RDF @ 160:80:80 NPK.The whole experimental plot was levelled after tillage practices and divided into plots of required size (3 $\times$4.2 m). The as per treatment dose of FYM was applied to each plot and incorporated well in the soil 10 days prior to sowing.

3. Result and discussion

Plant height was found significant influence by different integrated nutrient management. Plant height of Tulsi was measured at harvesting time (90 DAP) and presented in (Table-1). The maximum plant height (110.00 cm) was observed in T_3 (FYM 10 T ha^{-1}) +100%NPK treatment and lowest plant height (75.50cm) was obtained in control T_1. On the basis of effect of organic manures and fertilizer on plant height of Tulsi, the performance of treatments could be placed as the following order T3>T6>T4>T5>T2>T1. The maximum number of primary branch/plant (8.00) was appeared from T_3 (FYM 10 T ha^{-1}) +100%NPK treatment and lowest No. of branch/plant (3.25) was obtained from T_1(control- no fertilizer), No. of primary branch/plant of aromatic hybrid tulsi was significantly influenced by adding fertilizer and manures which were shown in (Table-1), the treatment could be placed inT3>T4>T5>T6>T2>T1in respect of impact on No. of branch/plant. The highest fresh biomass yield in the main crop (537.75 Quintal ha^{-1}) includes three ratoon crops with multicut after 90 days interval. The lowest fresh biomass yield per hectare was obtained in T_1(control- no fertilizer) alone (205.50 Quintal ha^{-1}). Nutrients through chemical fertilizer is expected to be more available that reflect on its uptake by plants leading to enhance the growth and yield. The maximum essential oil content (0.70 %) whereas the lowest essential oil content (0.31 %) was recorded in T_1(control- no fertilizer) in the hybrid aromatic tulsi crop. Oil yield per hectare increased with the increase of FYM doses, but with application of NPK T_3 (FYM 10 T ha^{-1}) +100%NPK recorded maximum oil yield in the tulsi crop (221 kg ha^{-1}) and the lowest oil yield (151.0 kg ha^{-1}) was obtained in T_1(control- no fertilizer). Integrated nutrient management improve the chemical, physical and biological soil proprieties that reflect positively on plant growth and oil yield. The similar result reported by Rahman et al (2014). From these results it was concluded that dose of fertilizer FYM (10T ha^{-1}) + 100% NPK (160:80:80 kg ha^{-1}) increase the growth, fresh biomass yield, oil content and oil yield in hybrid aromatic Tulsi crop.

Table 1. Effect of fertilizer application on growth and yield parameter in hybrid aromatic tulsi crop at 90 DAP

Treatment	Plant height	No of primary branches	Fresh biomass Quintal ha^{-1}	Essential oil content %	Oil yield Kg ha^{-1}
T_1(control- no fertilizer)	75.50	3.25	205.50	0.31	151.0
T_2 (FYM 10 T ha^{-1})	83.50	4.75	299.75	0.40	167.0
T_3 (FYM 10 T ha^{-1}) +100%NPK	110.80	8.05	537.75	0.70	221.0
T_4 (FYM 10 T ha^{-1}) + 75% NPK	97.00	6.02	465.50	0.60	191.2
T_5(FYM 10 T ha^{-1}) +50% NPK	84.00	5.02	424.25	0.51	177.5
T_6 (RDF @ 160:80:80 Kg NPK	97.75	4.77	421.50	0.50	173.2
SEm	1.01	0.157	4.26	0.005	2.20
CD 5%	3.04	0.474	12.85	0.016	6.63
CV %	2.21	5.93	2.17	2.15	2.44

Reference

Rahman KM, Sattar MA, and Rahman GMM 2014. Effect of fertilizer and manures on growth and yield of tulsi and pudina medicinal plant, *Journal of Environment Science and Natural Resources* **7**(2):13-16

4.19/T_4-80

Phytosociology of Important Non-Timber Forest Product Arborescent species in Western Himalayas

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Keywords: Phytosociology, NTFP, IVI

1. Introduction

NTFPs contribute significantly to livelihoods dependency of local people and diverse range of plants products are source of food, nutrition, fodder, fiber, medicine, dye, and other uses that meet household needs and generate profitable revenue in western Himalaya. The aim of study is to assess the phytosociological status and their utilization pattern in western Himalaya.

2. Materials and methods

The present study was carried out in Lansdowne Forest Division in Pauri district of Western Himalayas. A total of forty quadrate with a size of 20 x 20 m^2 for tree and 5 x 5 m^2 for shrub were laid to determine the community structure and species composition in the study area. The phytosociological status and diversity indices were determined by following standard formulae.

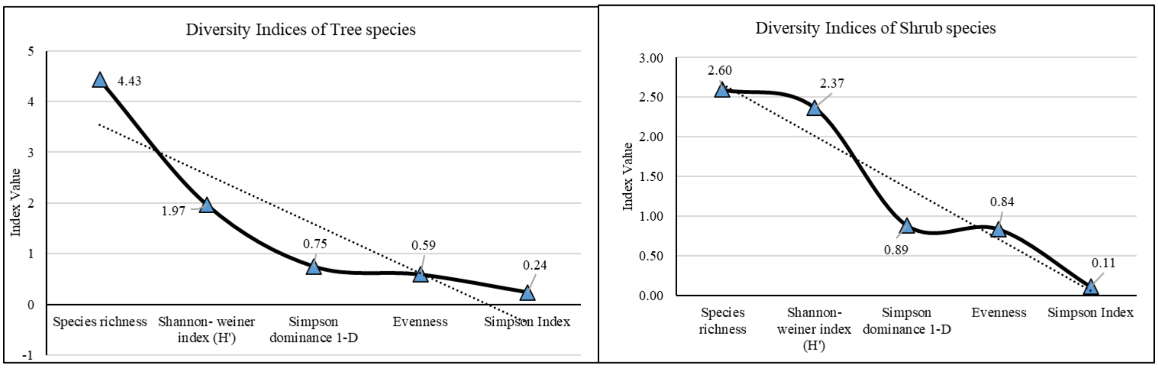

Figure 1: Different diversity indices for NTFPs

3. Results and discussion

This study reveals that highest basal cover was found for *Shorea robusta* (9,3082.04), and lowest for *Albizia lebbeck* (134.55) among tree species. However, the highest basal cover was recorded for *Murraya koenigii* (4.71/25m^2) and lowest for *Woodfordia fruticose* (0.07/25m^2) among shrub species. *Shorea robusta* had the highest density (101.88/ha), while *Aegle marmelos* had the lowest (0.63/ha). However, for shrub, *Eupatorium adenophorum* had highest density (2.00/25m^2), while lowest for *Carissa opaca* (0.05/25m^2). The maximum IVI was found for *Shorea robusta* (59.13), and minimum for *Albizia lebbeck* (1.83) in tree species. While, the highest IVI was found for *Lantana camara* (49.36) and minimum for *Glycosmis pentaphylla* (1.43) among shrub species. The NTFP species are documented with their uses in curing various ailments.

4.20/T_4-81

Preparation of Transparent Wood from *Bambusa bambos* (L.) Voss

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Keywords: *Bambusa* bambos, transparent wood, FTIR, optical property, environment friendly

1. Introduction

Bambusa bambos, belongs to the family poaceae with major distribution in southern Asia, central America, Java, Malaysia and the Philippines. The plant species is tall with heavily branched closely growing culms. It is extensively used in building bridges, ladders and building houses, now demonstrated for making as a transparent wood composite.

2. Material and methods

During the work, the bamboo (*bombusa bamboo)* was sourced from the Forest College and Research Institute wood processing unit. NaOH was used as one of Lignin Modification chemical. It is a bleaching agent which is effective in removing the partial removal and modification of lignin. The NaOH supplied by Tarnaka chemicals private Limited, 1-91, Habsiguda x roads, Hyderabad 500 007, Telangana. In the study H_2O_2 used as one of Lignin Modification chemical.

3. Results and discussion

It was noted that natural bamboo was having many anatomical features like pores, fibre bundles and vascular bundles features such as phloem, protoxylem, which were surrounded by parenchyma tissue as shown in plate.1 a and b. As shown in Figure, there were some hierarchy channels in wood which give the wood some scope for compression when stress was applied to the wood, but when hard material like resin filled in the hierarchy channels there was a good chance of increasing strength and toughness as seen in mechanical properties Fig. 1. Low and high magnification SEM images of TWA1 (Transparent bamboo) showed that the lumen of cell wall was filled with epoxy along with the interfacial bonding of nanofibrils with Epoxy.

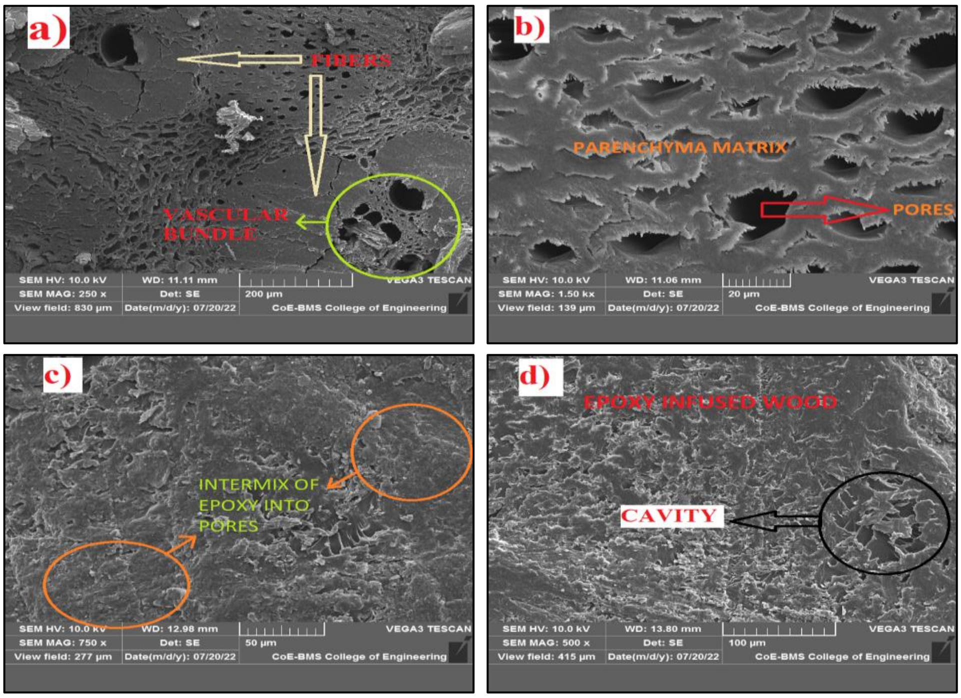

Figure 1. Samples a) and b) shows the NB with its anatomical features, Samples c) and d) shows the SEM images of Epoxy filled Bamboo

4.21/T$_4$-96

Zero Waste Utilization Concept for Preparation of Incense Stick

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Keywords: Incense stick, agarbatti, coating material, bamboo dust, bamboo charcoal

1. Introduction

Incense or Agarbatti stick is a globally traded product and is used in almost every household worldwide. Incense stick is having a bamboo core coated with fragrant materials. Bamboo is an important raw material in incense stick industry. In incense stick core processing unit there is nearabout 80 % wastage of bamboo. Hence for value addition and zero waste utilization in incense stick unit, present study was conducted.

2. Material and methods

The study was carried out at Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India. The experiment was conducted with coating material [bamboo dust and charcoal and Jigat (*Litsea sebifera* Pers. *Sebifera glutinosa* Lour. Bark powder)], commonly known as *masala*, prepared in different combinations of wood dust, bamboo dust, bamboo charcoal and jigat powder. Adequate amount of water was added to get the paste of coating material. Thereafter coating of coating material on the bamboo stick was done by machine. The 8 inches long sticks were used to prepare incense stick of which, the length of 6.5 inches was covered by the coating material. A premix from market was used as control.

3. Results and discussion

It was observed that incense sticks produced with different combinations were equally good to the aroma released by the incense sticks made using market premix. Observations on evaluation of masala and fire holding capacity and suitability to use as coating material revealed that all the incense sticks were equally good even after application of fragrance. Shelf life of all the incense sticks without application of fragrance liquid was more than one year at normal room condition. Burning time of these incense sticks was at par with incense sticks made with market premix. All the incense sticks produce less ash as compared to incense stick produced with market premix. Hence, bamboo waste is contributing quality in incense stick to substitute the wood. Therefore, findings will benefit the incense stick core processing units for zero waste utilization with additional profit.

Table 1. Evaluation of suitability to use as coating material for incense stick

Treatments	MHC	ARC	FHC	BA	TS	BT	Ash (gm)
Bamboo Charcol+Wood Dust+Jigat (30%+35%+15%)	✓	✓	✓	✓	✓	39.80	0.017
Bamboo Charcol+Wood Dust+Jigat (35%+50%+15%)	✓	✓	✓	✓	✓	38.39	0.030
Bamboo Charcol+Wood Dust+Jigat (40%+45%+15%)	✓	✓	✓	✓	✓	40.72	0.031
Bamboo Charcol+Bamboo Dust+Jigat (10%+75&15%)	✓	✓	✓	✓	✓	42.00	0.031
Bamboo Charcol+Bamboo Dust+Jigat (15%+70%+15%)	✓	✓	✓	✓	✓	40.69	0.033
Bamboo Charcol+Bamboo Dust+Jigat (20%+65%+15%)	✓	✓	✓	✓	✓	35.58	0.030
Bamboo Charcol+Bamboo Dust+Jigat (25%+60%+15%)	✓	✓	✓	✓	✓	39.18	0.031

Bamboo Charcol+Bamboo Dust+Jigat (30%+55%+15%)	✓	✓	✓	✓	✓	37.76	0.035
Bamboo Charcol+Bamboo Dust+Jigat (35%+50%+15%)	✓	✓	✓	✓	✓	40.17	0.043
Bamboo Charcol+Bamboo Dust+Jigat (40%+45%+15%)	✓	✓	✓	✓	✓	37.07	0.038
Bamboo Charcol+Bamboo Dust+Jigat (45%+40%+15%)	✓	✓	✓	✓	✓	36.52	0.034
Bamboo Charcol+Bamboo Dust+Jigat (50%+35%+15%)	✓	✓	✓	✓	✓	39.27	0.038
Bamboo Dust+Jigat (85%+15%)	✓	✓	✓	✓	✓	39.50	0.081
Premix (control)	✓	✓	✓	✓	✓	39.80	0.107
S.E.(m)						1.114	0.015
C.D. $_{(0.05)}$						3.165	0.042

MHC= Masala holding capacity; ARC=Aroma release capacity (manual test); Fire holding capacity (FHC); BA= Burning ability (Consistency and uniformity); TA=Transportation suitability; BT= Burning Time (minutes)

4.22/T_4-97

Effect of Pre-Harvest Treatments on Physical, Yield and Shelf-life of Sapota [*Manilkara achras* (Mill.) Fosberg] cv. Kalipatti

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Keywords: shelf-life, pre-harvest, climacteric, salicylic acid, calcium chloride

1. Introduction

Sapota occupies an area of 83 thousand ha with annual production of 10.03 lakh MT (Anon., 2020). The post-harvest losses in India are about 25-30%. So, enhancing the shelf-life of sapota fruits not only reduce post-harvest losses, but also increases its availability to consumers for longer period of time. Keeping this in view, this experiment was carried out to enhance the physical properties, yield as well as post-harvest life of sapota.

2. Materials and methods

Experiment was conducted on 31 years old tree with 10 treatments and four repetitions. Treatments were applied in two consecutive seasons (*i.e.*, Winter and Summer). For estimation of physical parameters Five randomly selected fruits from each treatment were used. The yield was calculated at each picking and averaged of two consecutive seasons. The shelf-life of fruits was noted by keeping the fruits at room temperature and the days taken from harvesting to optimal eating stage.

3. Results and discussion

During the winter (season-1) and summer (season-2) seasons of investigation, treatment T_8 (2000 ppm Salicylic acid + 1.5 % $CaCl_2$) recorded highest fruit weight (89.78 g and 88.34 g), length (5.73 cm and 5.66 cm), diameter (5.61 cm and 5.58 cm), volume (83.88 cc and 82.76 cc) and shelf life (10.46 and 10.35), respectively. A perusal of data revealed that various pre-harvest treatments did not have a significant influence on specific gravity. The same treatment recorded maximum fruit yield (165.90 kg tree^{-1}) as well as highest net return (₹ 202373) which was at par with T_5 (2000 ppm Salicylic acid + 1.0 % $CaCl_2$) (Table 1).

Table 1a. Effect of different pre-harvest treatments on physical attributes of sapota cv. Kalipatti

Treatments	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit volume (cc)	
	S-1	S -2	S-1	S -2	S-1	S -2	S-1	S -2
T_1	79.12	78.42	5.16	5.04	5.05	4.91	72.60	73.18
T_2	81.79	80.60	5.20	5.12	5.13	5.00	75.50	74.58
T_3	80.05	79.10	5.16	5.10	5.09	4.98	73.30	73.64
T_4	83.10	82.14	5.41	5.35	5.25	5.14	77.26	75.96
T_5	88.68	86.74	5.62	5.58	5.52	5.41	83.45	81.24
T_6	82.12	81.03	5.25	5.18	5.14	5.01	76.06	75.16
T_7	83.22	82.21	5.62	5.54	5.43	5.37	77.38	76.68
T_8	89.78	88.34	5.73	5.66	5.61	5.58	83.88	82.76
T_9	82.91	81.90	5.32	5.24	5.14	5.08	76.69	75.50
T_{10}	70.12	68.50	5.06	4.97	4.89	4.77	64.76	63.48
S. Em. ±	1.68	1.69	0.125	0.127	0.118	0.119	1.70	1.52
C. D. (5%)	4.87	4.88	0.362	0.367	0.340	0.345	4.90	4.40
C. V. %	4.11	4.18	4.69	4.82	4.52	4.66	4.46	4.05

b						
Treatments	Specific gravity		Shelf life (Days)		Fruit yield (kg tree^{-1})	Net Return (₹ ha^{-1})
	S-1	S-2	S-1	S-2	S-1+ S-2	
T_1	1.10	1.08	8.91	8.81	120.09	145826
T_2	1.08	1.08	9.11	9.00	126.61	154417
T_3	1.09	1.08	9.28	9.19	122.38	146356
T_4	1.08	1.09	9.68	9.60	153.19	188495
T_5	1.07	1.07	10.15	10.04	163.40	202802
T_6	1.08	1.08	9.41	9.33	145.86	174123
T_7	1.08	1.07	10.00	9.86	154.28	185882
T_8	1.07	1.07	10.46	10.35	165.90	202373
T_9	1.08	1.09	9.55	9.48	152.70	180417
T_{10}	1.08	1.08	8.73	8.65	114.97	139404
S. Em. ±	0.029	0.030	0.168	0.210	2.92	S-1= Season-1
C. D. (5%)	NS	NS	0.484	0.607	8.42	S-2= Season-2
C. V. %	5.45	5.70	3.52	4.46	4.11	

Reference

Anonymous (2020a). *Area and Production of Horticulture Crops*: *All India (2nd Advance Estimate).* National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Govt. of India. Retrieved from http://nhb.gov.in/ [Accessed 23 January, 2021].

4.23/T_4-98

Response of Different Organics Spray on Yield Characteristics of Sapota Fruits

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Keywords: Novel, cow-urine, panchgavya, TSS, shelf life

1. Introduction

India is considered to be the largest producer of sapota in the world. The area and production of sapota cultivation in India is 97 thousand ha and 11.76 lakh MT. While in south Gujarat, the area under sapota cultivation is 13.03 thousand ha with 1.58 lakh tonnes of annual production wherein its cultivation is concentrated mainly in Navsari, Valsad and Surat districts (Anon., 2020). The foliar application of cow urine, panchagavya and Novel Organic Liquid Nutrients plays a vital role in improving the quality and comparatively more effective for rapid recovery of plants. Keeping this in view, this experiment was carried out to enhance the physical properties, yield as well as post-harvest life of sapota.

2. Materials and methods

Experiment was conducted on 32 years old tree with 10 treatments and four repetitions. Treatments were applied in different number of spray with different concentration. For estimation of physical parameters Five randomly selected fruits from each treatment were used. The yield was calculated at each picking and averaged of two consecutive seasons. The shelf-life of fruits was noted by keeping the fruits at room temperature and the days taken from harvesting to optimal eating stage.

3. Results and discussion

During the winter (season-1) and summer (season-2) seasons of investigation, treatment T_9 (5% five spray of Novel Organic Liquid Fertilizer) recorded highest fruit weight (85.20 g and 82.00 g), fruit length (6.20 cm and 6.09 cm), fruit diameter (5.86 cm and 5.70 cm), fruit volume (78.20 cc and 74.18 cc) and fruit TSS (24.00 ˚B and 23.68 ˚B), shelf life (8.00 and 7.60) (Table 1). The same treatment recorded maximum fruit yield (174.30 kg tree^{-1}).

Table 1. Response of different organics spray on yield characteristics of sapota fruits

Treatments	Fruit weight (g)		Fruit length (cm)		Fruit diameter (cm)		Fruit volume (cc)	
	S-1	S -2	S-1	S -2	S-1	S -2	S-1	S -2
T_1	74.56	68.90	4.80	4.70	4.79	4.58	66.05	60.06
T_2	76.80	70.50	5.04	4.90	4.98	4.67	68.80	63.80
T_3	81.11	77.66	5.80	5.69	5.65	5.41	73.91	69.12
T_4	78.39	71.99	5.49	5.37	5.13	4.86	69.49	64.49
T_5	80.20	73.25	5.61	5.49	5.39	5.20	71.70	67.20
T_6	83.49	80.76	5.96	5.84	5.70	5.53	76.69	73.18
T_7	79.55	73.08	5.54	5.43	5.30	4.97	70.45	65.46
T_8	83.80	80.83	6.10	6.00	5.76	5.61	77.24	73.24
T_9	85.20	82.00	6.20	6.09	5.86	5.70	78.20	74.18
T_{10}	72.00	66.99	4.62	4.48	4.58	4.49	63.30	58.20
S. Em. ±	1.15		0.072		0.057		0.47	
C. D. (5%)	3.34		0.213		0.165		1.34	
C. V. %	4.24		3.70		3.09		1.93	

	TSS (˚B)		Shelf life (Days)		Total Fruit yield (kg $tree^{-1}$)
	S-1	S-2	S-1	S-2	S-1+ S-2
T_1	19.68	19.56	6.70	6.10	149.00
T_2	19.72	19.64	6.95	6.40	151.93
T_3	21.43	20.98	7.75	7.20	163.33
T_4	20.21	19.70	7.20	6.85	156.39
T_5	20.27	20.10	7.45	7.12	161.69
T_6	23.09	23.10	7.80	7.30	166.81
T_7	20.98	20.90	7.35	6.90	158.29
T_8	23.58	23.21	7.95	7.40	171.61
T_9	24.00	23.68	8.00	7.60	174.30
T_{10}	19.52	19.04	6.20	6.00	130.00
S. Em. ±	0.18		0.08		3.59
C. D. (5%)	0.53		0.23		10.37
C. V. %	2.49		3.17		4.54

Reference

Anonymous (2020a). *Area and Production of Horticulture Crops*: *All India (2nd Advance Estimate).* National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Govt. of India. Retrieved from http://nhb.gov.in/ [Accessed 23 January, 2021]

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Cultivated Aromatic Crops of Jammu and Kashmir, India: Industrial and livelihood potential

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Keywords: Carvacrol, thymol, aromatic plants, Kashmir

1. Introduction

Aromatic crops have been an excellent source of essential oils and bioactive molecules. The high value aromatic plants of temperate region of India have become major sector of trade in both developed and developing countries. Kashmir Himalayas is endowed with a wide range of aromatic plants. The Mediterranean type of climate in Kashmir is most suitable for the cultivation of these species. Lavender, thyme, rosemary, oregano and Artemisia have huge market in India as well as in other parts of the world.

2. Materials and methods

Aromatic crops *viz*. *Lavandula angustifolia*, *Thymus linearis*, *Rosmarinus officinalis*, *Origanum vulagare* and *Artemisia absinthium* were cultivated at Faculty of Forestry, Benhama, in District Ganderbal of Kashmir. The essential oil was extracted by hydro-distillation and was analysed by GC-MS to determine the concentration of principle constituents for industrial recognition.

3. Results and discussion

L. angustifolia has 25.27% linalool and 44.98% linayal acetate, which was at par with the international standards. *T. linearis* has essential molecules like Terpinenes (30.4%); Thymol (42.1%) and Carvacrol acetate (1.8%). *A. absinthium* has essential molecules of Boronyle acetate (26.5%); Montirpenes (28.1%) and p-Cymene (14.1%). *R. officinalis* has molecules of α – pinene (16.33): 1, 8-cineole (14.33) and Camphene (9.28%). *O. vulagare* has molecules of Terpinen-4-ol (10.45%); Carvacrol (37.25%) and Thymol (0.79%). The global market for lavender oil is estimated to reach an approximate valuation of US$ 201.6 million. Rosemary oil market is valued at nearly US$ 800 million. Hence, there is a lot of potential for commercial cultivation of these species in Kashmir.

Table 1. Essential oil composition (through GC-MS) of some aromatic herbs cultivated in Kashmir, India

S. No.	Crop	Molecules	Percentage
1	*O. vulagare*	Terpinen-4-ol	10.45
		Carvacrol	37.25
		Thymol	0.79
2	*T. linearis*	Terpinenes	30.40
		Thymol	42.10
		Carvacrol acetate	01.80
3	*L. angustifolia*	Linalool	25.27
		Linalyl acetate	44.98
		Lavandulyl acetate	3.44
4	*R. officinalis*	α - pinene	16.33
		1, 8-cineole	14.33
		Camphene	9.28
5	*A. absinthium*	Boronyle acetate	26.50
		Montorpines	28.10
		p-Cymene	14.10

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Morphological and physical properties of bamboo species in South Gujarat, India

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Keywords: Clump, culm, yield, moisture content, basic density

1. Introduction

Bamboo is a versatile, fast-growing woody perennial grass belonging to the family poaceae and considered as one of the important non-timber forest products (Pathak *et al*. 2017). The morphology and physical characteristics of bamboo vary between species and among the culm which influence the utilization patterns of the bamboo species for various industrial applications. (Amlani *et al*. 2017). Therefore, a study was carried out to understand the morphological and physical properties of various bamboo species in South Gujarat.

2. Material and methods

The present study was carried out on six bamboo species *i.e*., *Dendrocalamus strictus* (Roxb.) Nees, *Dendrocalamus stocksii* (Munro.), *Dendrocalamus hamiltonii* Gamble, *Bambusa vulgaris* Schrad. ex J. C. Wendl. (Green), *Bambusa balcooa* (Roxb.), and *Bambusa bambos* (L.) planted at bambusetum, College of Forestry, Navsari Agricultural University, Navsari, Gujarat. Total five (4-year-old) culms per clump of each species were randomly selected and harvested for the study. Morphological properties such as clump height and girth, culm length and diameter, internodal length and mid-diameter of entire culm; culm weight, number of culms per clump and total yield were recorded. Cross sectional samples were used for evaluation of physical properties *i.e*., moisture content, basic density and hollowness proportion.

3. Result and discussion

The highest clump height (11.25 m) and internodal length (27.77 m) were recorded in *B. vulgaris*. The maximum clump girth (7.38 m) was recorded in *B. balcooa.* Culm diameter (3.87 cm) and internodal mid-diameter (4.02 cm) were recorded highest in *B. bambos*. However, the maximum biomass in terms of yield per clump was recorded in *D. strictus* (299.90 kg) followed by *B. bambos* (238.52 kg) and *B. balcooa* (188.99 kg). It was observed that the moisture content in each bamboo species varied inversely with basic density. The highest basic density (0.693 g/cm^3) and the lowest moisture content (64.58 %) was recorded in *B. balcooa* followed by *B. vulgaris*, while the lowest basic density (0.505 g/cm^3) and high moisture content (121.66 %) was recorded in *B. bambos* followed by *D. hamiltonii*. The minimum (2.35%) and maximum (27.32%) hollowness was recorded in *D. stocksii* and *B. bambos*, respectively. It is concluded that, among six selected bamboo species, *D. strictus* and *B. bambos* performed better for biomass in terms of yield per clump in south Gujarat. Considering the physical properties, *B. vulgaris* and *B. balcooa* showed higher basic density than rest of the bamboo species. Hence, bamboo culms and their clumps could be characterized by individual growth, biomass and physical attributes for further utilization.

References

Amlani M H, Tandel M B, Prajapati V M, Pathak J G and Behera L K 2017. The Assessment of growth variation among different species of Bamboo. *International journal of chemistry studies* **5**(6): 1436-1439.

Pathak J G, Tandel M B, Amlani M H, Chavda JR and Prajapati J R 2017. Growth evaluation of long internode bamboo species in South Gujarat. *Journal of Tree Science* **36**(2):40-44.

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Fuel Bark Quality Evaluation of Commercial Tropical Tree Species: An Approach to Waste Utilization

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Keywords: Fuel value index, ash, basic density, moisture content, calorific value

1. Introduction

The removal of bark from logs is creating major residue problem in wood-based industries. It contains high amount of lignin, extractives, ash & moisture and low amount of polysaccharides than wood (Harkin and Rowe 1971). The most desirable properties for an optimal fuel quality of a lignocellulosic material are its high calorific value, high density, low ash and moisture content (Puri et al 1994). Keeping in view of these points, a research study was carried out to evaluate the fuel value index of bark from ten commercially important tropical tree species for their efficient utilization.

2. Material and methods

A total of ten different tree species planted in NAU campus were selected for determination of calorific value, basic density, moisture and ash content of bark. The moisture content of the collected bark was determined by oven-dry method, while basic density was determined by water displacement method. The bark sample was pelleted and burnt in an oxygen bomb calorimeter to determine the calorific value. However, ash content was determined by burning one gram of powdered bark sample in the muffle furnace at temperature of 600°C.

3. Results and discussion

Among the tree bark of selected ten species, the lowest and the highest moisture content was recorded in *Acacia nilotica* (58.30%) and *Albizia procera* (298.02%), respectively. The highest basic density was found in *Casuarina equisetifolia* (0.600 g/cm^3), while lowest basic density was found in *Albizia procera* (0.277 g/cm^3). Highest ash content was reported in *Tectona grandis* (13%), whereas lowest ash content

Table 1. Fuel value ranking of bark of the ten commercially important tree species using calorific value, density, ash, moisture and fuel value index (FVI). The ranking ranges from 1 (best) to 10 (worst)

Tree species	Moisture content (%)	Basic density (g/cm^3)	Ash content (%)	Calorific value (cal/g)	FVI	Total	Rank
Tectona grandis	8	8	10	9	10	45	10
Gmelina arborea	9	7	2	3	6	27	6
Casuarina equisetifolia	2	1	3	8	1	15	1
Eucalyptus spp.	7	9	8	10	9	43	9
Mangifera indica	3	3	7	6	5	24	5
Albizia procera	10	10	5	1	8	34	8
Acacia nilotica	1	2	9	4	2	18	3
Acacia auriculiformis	4	4	4	5	4	21	4
Adina cordifolia	5	6	1	2	3	17	2
Leuecena leucocephala	6	5	6	7	7	31	7

in *Adina cordifolia* (5.30 %). The highest and the lowest calorific value was recorded in *A. procera* (17.66 MJ/kg) and *Eucalyptus* spp. (14.97 MJ/kg), respectively. The highest fuel value index (FVI) was assessed in *Casuarina equisetifolia* (156.80) and lowest in *Tectona grandis* (18.53). Based on the ranking of the tree species with respect to their fuel value characteristics of bark, the highest fuel bark quality was found in *C. equisetifolia* followed by *Adina cordifolia* and *Acacia nilotica*, while the lowest fuel bark quality was found in *Tectona grandis*. It is concluded that the maximum fuel bark quality was evaluated in *C. equisetifolia.* followed by *Adina cordifolia*, *A. nilotica*. However, *Acacia auriculiformis* and *Mangifera indica* also recorded topper rank other five species. Therefore, the waste bark of these tree species could be further utilized into the value-added products like briquettes.

References

Harkin JM and Rowe JW 1971. *Bark and its possible uses*. Research Note. USDA, Forest Products Laboratory, Madison, pp.1-56.

Puri S, Singh S, and Bhushan B 1994. Fuelwood value index in components of ten tree species of arid region in India. Industrial Crops and Products **3**:69-74.

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Processing and Value Addition of *Aloe vera* to Enhance Sensory Acceptability

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Keywords: *Aloe vera* juice, Aloin, Vermicelli, Dehydrated gel, Quality, Storage

1. Introduction

Aloe vera is known from centuries for being used to care degenerative diseases. Therefore, different value added product viz. Aloe vera juice, nectars, vermicelli and dehydrated Aloe vera gel can be prepared from the Aloe vera by applying different approaches of processing and value addition. However, commonly occurring problem in consumption of these commodities in fresh from is due to its bitter taste (*Aloe vera*, bitter gourd) and highly acidic as well as astringent taste (aonla). Guava fruits besides having medicinal importance also possess good flavour and acceptability; thus having positive attribute for blending purpose.

2. Materials and methods

The present investigation was aimed to standardize pre-treatment for removal of the bitter compound 'aloin' from *Aloe vera* gel, to standardize formulation for preparation of *Aloe vera* based vermicelli, to optimize suitable drying temperature for dehydration of *Aloe*. First experiment was conducted for removal of the bitter compound 'aloin' from *Aloe vera* gel. Second experiment was conducted for preparation of vermicelli using seventeen treatment formulations of *Aloe vera* juice. Third experiment was conducted for drying of *Aloe vera* gel using nine dehydration temperature. Further experiment was conducted to study the effect of blending proportions on the quality of blended Aloe vera nectar using juice of *Aloe vera*, bitter gourd, aonla and guava.

3. Results and discussion

The results indicated that aloin free *Aloe vera* gel obtained by giving pre-treatment with 7.5 % ethanol for 3 hours to *Aloe vera* piece having preparation size of 5 cm was found superior based on minimum aloin content. The vermicelli prepared using 24 % *Aloe vera* juice, 1 % isabgol husk, 75 % wheat flour found superior based on stability of nutritional as well as higher sensory quality during six months storage. Drying of *Aloe vera* gel at four stage dehydration temperatures was found superior based on stability of nutritional and higher sensory quality attributes during six months storage. The nectar prepared from 12% *Aloe vera* juice, 2% Bitter gourd juice, 2% Aonla juice and 4% Guava pulp having 16.00°Brix TSS and 0.30 per cent acidity was extremely liked on the basis of 9-point Hedonic scale and found best on the basis of nutritional composition. The aloin free *Aloe vera* juice can be obtained by giving pre-treatment with 7.5 % ethanol for 3 hours to *Aloe vera* piece having preparation size of 5 cm. *Aloe vera* juice can be utilized for vermicelli preparation by using formulation of 24 % *Aloe vera* juice, 1 % isabgol husk, 75 % wheat flour. *Aloe vera* gel can also be utilized for dehydration at four stage dehydration temperature of 75°C for 2 hours, 70°C for 3 hours, 65°C for 4 hours and 60°C for about 10 hours. Further blended nectar can be prepared by using 12% *Aloe vera* juice, 2% Bitter gourd juice, 2% Aonla juice and 4% Guava pulp having 16°B TSS and 0.30% acidity.

Table 1. Effect of blending formulation on total sugars, ascorbic acid and phenol contents of blended nectar during storage

AV: BG: AO and GV Blends (B)	Sodium (mg/100g)				Potassium (mg/100g)				Overall acceptability			
	Storage (Month)			Mean (B)	Storage (Month)			Mean (B)	Storage (Month)			Mean (B)
	0	3	6		0	3	6		0	3	6	
B_1-2:2:12:4	48.32	48.30	48.25	48.29	26.81	26.80	26.78	26.79	7.45	6.81	6.48	6.92
B_2-2:12:2:4	64.52	64.50	64.45	64.49	33.50	33.49	33.48	33.49	7.17	7.15	6.99	7.10
B_3-4:4:8:4	48.23	48.22	48.18	48.21	28.88	28.87	28.85	28.86	7.37	7.20	6.85	7.14
B_4-4:6:6:4	48.65	48.62	48.60	48.62	22.10	22.08	22.05	22.08	7.74	7.64	7.58	7.65
B_5-4:8:4:4	52.12	52.10	52.00	52.07	30.48	30.45	30.43	30.45	7.57	7.60	7.35	7.51
B_6-6:4:6:4	47.70	47.65	47.65	47.66	30.33	30.32	30.30	30.31	7.75	7.45	7.27	7.49
B_7-6:6:4:4	48.28	48.25	48.23	48.25	25.16	25.15	25.13	25.14	7.85	8.01	7.80	7.88
B_8-8:4:4:4	47.31	47.28	47.25	47.28	25.75	25.72	25.70	25.72	8.32	8.32	8.13	8.25
B_9-12:2:2:4	45.34	45.33	45.28	45.32	17.58	17.56	17.53	17.56	8.80	8.60	8.34	8.58
Mean (T)	50.05	50.03	49.99	50.02	26.73	26.71	26.69	26.71	7.78	7.64	7.42	7.61
$CD_{0.05}$	B=0.02 S=NS B =NS				B=0.02 S=NS B =NS				B=0.06 S=0.03 B =0.09			

References

Elbandy MA, Abed SM, Gad SSA and Abdel-Fadeel MG 2014.Aloe vera gel as a functional ingredient and natural preservative in mango nectar. *World J. Dairy Fd. Sci.*, **9**(2): 191-203.

Hamid GH, Ei-Kholany EA and Nahla EA 2014. Evaluation of aloe vera gel as antioxidant and antimicrobial ingredients in orange-carrot blend nectars. *Middle East J. Agric. Res.*, **3**(4): 1122-1134.

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Processing and Value Addition of 'Noni' (*Morinda citrifolia* L.) Fruits

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1. Introduction

'Noni' *(Morinda citrifolia* L) fruit tree belongs to family Rubiaceae. It starts bearing fruits in about 18 months and yields 6–8 kilograms of fruit every month throughout the year having 72-96 kg fruits per anuum. It is a multiple fruit possessing pungent odour upon ripening and hence also known as cheese fruit or vomit fruit. However, despite its strong smell and bitter taste, the fruit / juice is nevertheless used as a famine food to treat several ailments like arthritis, cancer, joint pains, headaches, diabetes, hypertension, asthma, immune system failure, indigestion etc. Noni fruit juice act as a cellular diet and works at a cellular level to treat the ailment. 'Noni fruit juice is rich in phyto-chemicals. Extraction of the 'noni' juice from the ripe fruits is a very difficult and the recovery of the juice by pressing is very less. Therefore, present investigation was undertaken to standardize suitable method for extraction of juice to enhance juice recovery and, nutritional qualities for further value addition.

2. Materials and methods

The experiment was conducted to study the effect of enzymatic treatments on the recovery of noni juice at Centre of Excellence, Department of Post Harvest Technology, ACHF, NAU. Sixteen different enzyme treatments (Pectinase, cellulose and their combinations) were used for extraction of the 'Noni' fruit juice. The juice after extraction filtered, heat pasteurized and packed in glass bottles followed by processing (96±1ºC) for 30 min. The juice was stored for 12 months to study the storage stability. The analysis of parameter was done as per standard method described by S. Ranganna (1996). The juice obtained form best treatment was also used for blending with mango pulp with 12 treatments for preparation of blended Noni mango nectar.

3. Results and discussion

'Noni' fruits were used for extraction of the juice and their utilization. Different treatments were used for extraction of the 'Noni' fruit juice and results revealed that treatment of the crushed fruits with 0.1% Pectinase for 3 hours gave maximum 50.52% juice recovery by manual pressing against manual pressing without enzyme (31.71%). Results shows significant differences in ascorbic acid of noni juice when extracted using different treatments at '0' month, with maximum ascorbic acid (120.10mg/100g) in juice extracted using 0.10% pectinase (T3) and minimum in control (T1). During storage period of 12 months there was slight decrease in the ascorbic acid. After 12 months of storage significant differences were observed in ascorbic acid of juice, with maximum ascorbic acid (108.15 mg/100g) in juice extracted using 0.10% pectinase (T3) and minimum pooled ascorbic acid (92.05 mg/100g) in juice extracted using without enzymes (T1). Colour, body and overall acceptability of noni juice was observed to be significantly affected by extraction methods. Maximum colour, body and overall acceptability score (9 point Hedonic scale) were observed when juice was extracted using 0.15% pectinase (T4) at par with 0.10% pectinase (T3). During storage maximum stability in the organoleptic scores were observed in T4 at par with T3. During storage also significant differences were observed for colour, body and overall acceptability. Further, results on value addition of noni juice shows that juice can be utilized for the preparation of blended Noni mango nectar to increase the acceptability of the noni juice. Blended Noni mango nectar, prepared using 5% Noni fruit juice and 15% mango pulp followed by maintaining 16ºBrix TSS and 0.3% acidity of the nectar remained shelf stable for the period of 6 months and found more acceptable on the basis of sensory scores and nutritional composition (Anon. 2016). Therefore, noni juice can be extracted by treatment of the crushed fruits with 0.1% pectinase for 3 hours to get higher juice recovery (50.52%). The extracted juice remains shelf stable for 12 months at ambient temperature without any spoilage and contamination. The blending of noni juice (5%) with mango fruit pulp (15%) found to mask the effect of the pungent odour to great extent and so possess potential for preparation of ‘Noni Mango Nectar’.

Reference

Anon. 2016. Horticulture and Agro-Forestry Research Report. In: 12th meeting of Combined Joint AGRESCO of Horticulture and Agro-Forestry Research Sub Committee March 2016. Director of Research, NAU Navsari. Pp. 221-256.

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Sustainable bark harvesting techniques in *Pterocarpus marsupium* Roxb.

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Keywords: Indian Kino, medicinal tree, narrow strip, bark recovery, sustainable harvesting

1. Introduction

Indian Kino, *Pterocarpus marsupium* Roxb. (Fabaceae) is an important traditional medicinal tree species. Bark has been widely used for different ethnomedicinal treatments especially for diabetes and as a natural dye due to the presents of various metabolites and natural antioxidants. It has been placed in the red data book (near threatened) due to its over exploitation in the wild and unsustainable harvesting for its bark and gum. The population status of this species can be conserved and prevent further depletion by using sustainable harvesting technology for bark and gum kino for commercial exploitation.

2. Materials and methods

In this study, four different treatments were imposed for sustainable bark harvesting of *Pterocarpus marsupium* during 2020-21 at College of Forestry, Sirsi, Uttara Kannada. Total of four treatments imposed were *viz.*, T1: 10×10 cm with open patch, T2: 10×10 cm patch covered with polythene sheet, T3: 20×5 cm with open patch and T4: 20×5 cm patch covered with polythene sheet. Bark healing properties were assessed with intervals of 4 months as ‘per cent area of bark recovered.

3. Results and discussion

Significant variation in bark recovery was recorded among the treatments. The maximum bark recovery (77.20%) was recorded in the narrow strip patches (20×5cm) covered with polythene sheet as compared to other three treatments in the initial four months followed by opened narrow strip patches (20×5 cm: 58.60%)). After 8 months, the narrow strip patches (20×5cm) covered with polythene sheet showed highest bark recovery (95.60%) as compared to other three treatments. The least bark recovery (59.0%) was recorded in opened square patches (10×10 cm). It is interestingly recorded that the sheet type of bark recovery growth was only occurred in treatments covered with polythene sheet; whereas, the edge type of bark recovery growth was occurred in treatments which are not covered with polythene sheet (open patches). This may be due to exposure of bark removed area and loss of moisture content rapidly in open patches. Hence, in *Pterocarpus marsupium* narrow strips covered with polythene sheet is considered to be the best practice for sustainable harvesting of the bark.

Table 1. Bark recovery percentage of *Pterocarpus marsupium*

Sl. No	Treatment	Bark recovery (%)		
		After 4 months	After 8 months	Mean
1	T1: Square strip-open (10×10 cm)	34.60 (35.70)	59.00 (50.48)	46.80 (43.09)
2	T2: Square strip- covered (10×10 cm)	54.00 (47.52)	71.60 (59.29)	62.80 (53.40)
3	T3: Long strip -open (20×5 cm)	58.60 (49.93)	81.40 (68.30)	70.00 (59.12)
4	T4: Long strip-covered (20×5 cm)	77.20 (61.54)	95.60 (80.66)	86.40 (71.10)
	Mean	56.10 (48.67)	76.90 (64.68)	
	SEm±	4.13	4.58	
	C.D. (5%)	12.86	14.28	

* The values in parentheses are arc sine transferred values

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Diversity of Bee Flora in Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

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Keywords: Bee flora, diversity, nectar, pollen

1. Introduction

Plant that yields nectar and pollen is collectively referred as bee-pasture or bee-flora. For setting up apiculture unit in an area the study of bee flora is prerequisite. Bee flora differ from one place to another place because of change in climatological, topographical factors and environmental factors. Hence the aim of study is to identify the bee-flora and study of abundance. It is major prerequisite to study of availability of flora in campus area for successful beekeeping.

2. Material and methods

The study was conducted in Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola main campus. The bee flora survey was conducted for Identification of bee flora and classified them into respective categories. Further the bee flora classified according to the vegetation type like agricultural crops, horticultural crops, vegetable crops, forest crops and forest species, ornamental plants and weeds present at study site. The identified bee flora were observed for 10 minutes at least three bees should be visited to the flowers then it is called as bee flora. The bee flora abundance was calculated by the formula,

$$Percentage\ of\ abundance\ of\ bee\ flora = \frac{no.of\ bee\ flora\ species\ in\ particular\ month}{total\ no.of\ bee\ flora\ species.} \times 100$$

3. Results and discussion

The total number of 171 plant species has been recorded as bee-flora at study site in 61 different botanical families. Among this 13 were recorded as agricultural crop, horticultural crops (49), forest tree species (70) and wild plants including weeds and grasses (34) were recorded as bee flora. Out of which 13 species are nectariferous, 39 species polleniferous and 110 species are both. The Fig 1 revealed that availability of bee flora was recorded maximum in the month of April followed by May. Whereas minimum was recorded in the month of January and December. So it is concluded that the study area has full potential of bee-flora availability and abundance.

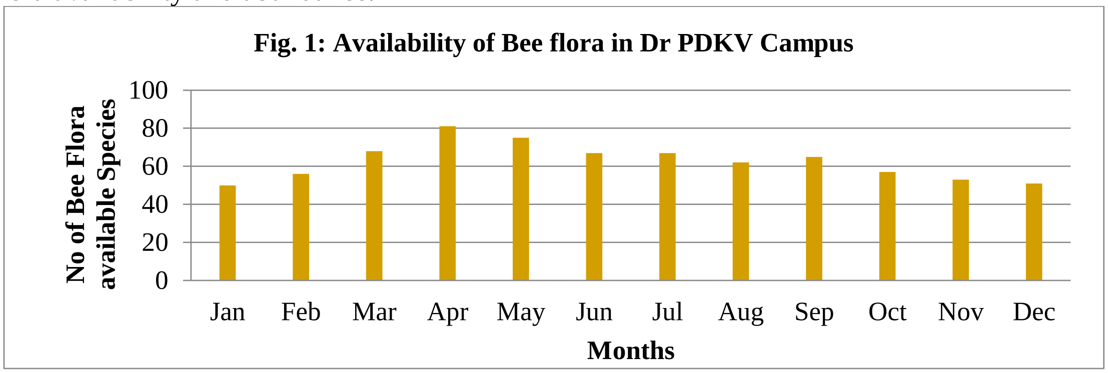

Figure 1. Periodic bee floral activity (No. of bees flora)

References

Pande R and Ramkrushna GI 2018. Diversification of Honeybee’s flora and bee flora calendar for Nagpur and Wardha districts of Maharashtra, India. *J. Entomol. Zool. Stud*. **6**(2):3102-3110.

Vidya KC, Kandakoor SB, Prabhu ST and Talekar SC 2020. Study on the diversity of bee flora in university of Agriculture sciences, Dharwad campus, Karnataka, India. *International Journal of Current Microbiology and Applied Sciences* **9**(11): 3365-3376.

4.31/T_4-135

Pharmacognostic Potential of Wild Edible Fruits – A Review

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Keywords: Wild fruits, pharmacognostic properties, pharmaceutical industry

1. Introduction

Wild species are supporting one billion population around the world. People rely on and getting benefit from the use of 50,000 wild species on a day-to-day basis for food, medicine, energy, income and many other purposes. More than 10,000 wild species are harvested directly for human food. Utilization value and quantity has enormously increased over the year and on other hand the sustainable management practices are not followed as per the requirement. It has created the large gap between the resource management and utilization aspects of wild plant resources specially in tropics. The Wild Edible Fruits (WEFs) contribute significantly to the food security, especially nutritional security of forest dependent communities where the primary or only source of fruits are from wild. Present study of review is helpful to obtain information about biochemical and physical properties of wild edibles especially wild fruits.

2. Materials and Methods:

Published literatures related to pharmacognostic potential of wild edible fruits were reviewed and referred to. Relevant research works focusing on diversity of the wild plants, dependency, demand, their pharmacognostic potential were reviewed properly. Outcomes of the various studies were presented to highlight the importance of wild edible fruits for human health and their role in forest dependent communities.

3. Results and discussion

In this review it is found that, dietary use of wild fruits appears in numerous records however there is lack of report about the nutritional potential of wild edible fruits in many cases. The published studies revealed that, consumption of fruits helps in prevention and cure of diseases and keep the normal well-being of human population. Even different varieties of the same species display considerable differences in bioactive compounds. Fruits of wild flora may have the potential to confer beneficial health effects due to their antioxidant activity and the total phenolic compounds and flavonoids. Many researchers have demonstrated that WEFs possess stronger phenolic content and antioxidant activity than the cultivated species in many fruits like apple, citrus *etc*. The forest dependent communities' wild fruits have also been found to improve household food security and sometime they earn cash income. In our country much of the wild fruits are underutilized with no proper conservation plan. WEFs has great potential in pharmaceutical industry as sources of diverse bioactive compounds. However, detailed analyses of the health promoting bioactive compounds of many WEFs and their nutraceutical applications are lacking which needs further investigation. After analyzing the many literatures, it is found that, proper conservation measures have to be taken to protect our endemic and threatened WEFs which are potential source to meet the nutritional requirement of the majority of the local communities. WEFs with potential clinical and wellness values can be brought under domestication through genetic improvement. Value addition and fair market linkages can be created to sustainable utilization of these resources and to reduce the pressure on natural sources.

References

Rao MJ, Wu S, Duan M and Wang L 2021. Antioxidant metabolites in primitive, wild, and cultivated citrus and their role in stress tolerance. *Molecules* **26 (19)**: 1-18.

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) 2022. *Summary for policymakers of the thematic assessment of the sustainable use of wild species.* Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Germany, p 33.

4.32/T_4-141

Sustainable Bark Harvesting Techniques in *Vateria indica* L.

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Keywords: White dammar, narrow strip, bark recovery, sustainable harvesting.

1. Introduction

Vateria indica L., commonly known as white dammar or Indian copal, belongs to Dipterocarpaceae family. Bark of the tree exudes agum-resin called white dammar or Dhupa; which is widely used in varnish industry, making of incense sticks, candles and soaps. The species is listed as critically endangered (CR) under IUCN red data book due to its over exploitation and unsustainable harvesting for gum. Sustainable harvesting technique is the key to extract bark and oleo-resins without causing any further depletion of the species.

2. Material and methods

In this study, four different treatments were imposed for sustainable bark harvesting of *Vateria indica* during 2020-21 at College of Forestry, Sirsi, Uttara Kannada. A total of four treatments were imposed *viz.*, T_1: 10×10 cm with open patch, T_2: 10×10 cm patch covered with polythene sheet, T_3: 20×5 cm with open patch and T_4: 20×5 cm patch covered with polythene sheet. Bark healing properties were assessed at intervals of 4 months as 'per cent area' bark recovered.

3. Results and discussion

A significant variation was observed among the different treatments. After four months of bark harvest, the highest bark recovery (43.00%) was recorded for the narrow strip patch (T4: 20×5 cm; patch covered with polythene sheet), followed by the opened narrow strip patches (T3: 20×5 cm: 34.00%) and the least bark recovery (17.00%) was recorded for square patch (T1: 10×10 cm; open patch).

Table 1. Sustainable harvesting of bark in *V. indica*

Sl. No	Treatment	Per cent bark recovery		
		After 4 months	After 8 months	Mean
1	T1: Square strip-open (10×10 cm)	17.00 (20.70)	31.00 (33.28)	24.00 (26.99)
2	T2: Square strip- covered (10×10 cm)	24.60 (26.58)	43.00 (40.15)	33.80 (33.36)
3	T3: Long strip -open (20×5 cm)	34.00 (32.42)	61.00 (51.51)	47.50 (41.97)
4	T4: Long strip-covered (20×5 cm)	43.00 (40.34)	70.00 (60.53)	56.50 (50.43)
	Mean	29.65 (30.01)	51.25 (46.37)	
	SEm±	4.31	4.77	
	C.D. (5%)	13.41	14.86	

* The values in parentheses are arc sine transferred values

After eight months of bark harvesting, highest bark recovery (70.00%) was recorded for the narrow strip patches (20×5cm) covered with polythene sheet as compared to other three treatments, and the lowest (31.00%) was recorded in opened square patches (10×10 cm). It was intriguing to note that, treatments covered with polythene sheets had both sheet and edge type of bark recovery; whereas, open patches treatments (not covered with polythene sheets) showed, edge type of bark recovery. This might be due to loss of moisture content in exposed patches. Some trees responded poor bark recovery due to fungus and insect infestation. Hence, narrow strips covered with polythene sheet might be the best practice for sustainable harvesting of *Vateria indica* bark.

4.33/T_4-144

Development of a Mahua (*Madhuca longifolia*) Seed Decorticator and Value Addition of Mahua Seed

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Keywords: Concave clearance, decorticator, Mahua seed moisture content, performance

1. Introduction

Mahua (*Madhuca longifolia*) seed is a tree-borne oilseed and one of the important non-timber forest products of India. The seeds are primarily processed for their oil which is used in various food and non-food industries. Prior to extraction of oil, mahua seeds are manually broken to obtain mahua kernel. The manual decortication process is tedious and time consuming and labour-intensive process costly, low output and injurious to human being. To overcome this problem, present investigation was carried out to design and develop a mahua seed decorticator and its performance was evaluated.

2. Materials and methods

The decorticator was designed employing SOLIDWORKS 2020 and fabricated using standard procedure. The components of machine comprise of the main frame, feed hopper, decorticating casing, a mechanism for adjusting clearance between concave and rotor assembly and a power transmission unit etc. The performance parameters of the decorticator were tested and evaluated with independent variables, namely four levels of seed moisture content, i.e., 9, 12, 15 and 18 % (db), and four levels of concave clearance, *i.e.*, 9, 11, 13 and 15 mm. With FCRD, there were 16 combinations which were considered as treatments and each treatment had three repetitions.

3. Results and discussions

The results revealed that independent parameters seed moisture content (M) and concave clearance (C) significantly affected the decorticating performance of mahua seed decorticator. At any particular concave clearance from 9 to 11 mm, per cent of whole kernel decreased as moisture content increased from 9% to 18% (db) while per cent of broken kernel and powder decreased as moisture content increased from 9% to 18% (db).

Table 1. Performance of mahua seed decorticator at different variables for factorial CRD design

Treatments	CC, mm	% of WC	% of BKP	%of PDS	%of UDS	DE, %	OME, %	Desirability
				Seed moisture content (M_1), 9 % db				
T_1 (M_1C_1)	9	58.87	13.19	0.79	0.56	98.65	80.59	0.312
T_2 (M_1C_2)	11	67.25	7.26	1.03	0.79	98.18	88.63	0.932
T_3 (M_1C_3)	13	63.05	7.45	2.31	1.12	96.57	86.36	0.732
T_4 (M_1C_4)	15	61.26	6.33	2.62	2.13	95.25	86.34	0.615
				Seed moisture content (M_2), 12 % db				
T_5 (M_2C_1)	9	58.12	12.83	1.14	0.91	97.95	80.24	0.080
T_6 (M_2C_2)	11	65.45	7.11	1.33	1.56	97.11	87.60	0.880
T_7 (M_2C_3)	13	64.13	6.67	2.69	2.27	95.04	86.09	0.679
T_8 (M_2C_4)	15	60.79	6.15	2.98	2.35	94.67	85.97	0.561
				Seed moisture content (M_3), 15 % db				
T_9 (M_3C_1)	9	57.79	12.66	1.56	1.45	96.99	79.56	0.037
T_{10} (M_3C_2)	11	64.67	6.45	1.81	1.93	96.26	87.53	0.828
T_{11} (M_3C_3)	13	62.04	6.11	2.87	2.56	94.57	86.10	0.625
T_{12} (M_3C_4)	15	60.38	6.00	3.12	2.61	94.24	85.72	0.496

Seed moisture content (M_4), 18 % db								
T_{13} (M_4C_1)	9	57.12	12.4	1.65	1.57	96.78	79.52	0.134
T_{14} (M_4C_2)	11	62.90	6.00	2.15	2.64	95.21	86.92	0.763
T_{15} (M_4C_3)	13	60.93	5.90	2.70	2.65	94.40	86.07	0.553
T_{16} (M_4C_4)	15	59.01	5.82	3.33	2.90	94.02	85.59	0.036

CC = Concave clearance WC =whole kernel; BKP = broken kernel and powder; PDS = partially decorticated seed; UDS = un-decorticated seed; DE = Decorticating efficiency and OME = Overall machine efficiency

Similarly, per cent of partially decorticated seed and per cent un-decorticated seed decreased as moisture content increased from 9% to 18% (db). At any particular concave clearance from 9 to 11 mm, decorticating efficiency (%) decreased with increased in moisture content from 9% to 18% (db) and decreased with increased in concave clearance from 9 to 15 mm. At any particular concave clearance from 9 to 11 mm, overall machine efficiency (%) decreased with increased in moisture content from 9% to 18% (db). But, at any particular moisture content from 9 to 18% (db), the overall machine efficiency (%) did not showed any particular trend with respect to concave clearance. Installed cost of developed mahua seed decorticator was Rs 32,000/- with a through put capacity of 100 kg/h. The best performance of mahua seed decorticator was obtained in treatment: T_2 (M_1C_2) i.e. at seed moisture content of 9% (db) and concave clearance of 11 mm which resulted in maximum percentage of whole kernel recovery of 67.25% with decorticating efficiency of 98.18% and overall machine efficiency of 88.63% having a desirability value of 0.932.

References

Hegde H T, Gunaga R P and Thakur N S 2018.Variation in seed oil content among 13 populations of Mahua [*Madhuca longifolia* var. *latifolia* (Roxb.) A. Chev.] in Gujarat. *International Journal of Chemical Studies* **6**(5):35-38.

Pradhan R, Naik S N, Bhatnagar N and Vijay V K 2010. Design, development and testing of hand-operated decorticator for Jatropha fruit. *Applied Energy* **87**:762-768.

4.34/T_4-146

Evaluation of some Anatomical Features of Shisham Wood from Rajasthan

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Keywords: Anatomy, *Dalbergia sissoo,* vessel length, fibre length

1. Introduction

Dalbergia sissoo Roxb. ex DC, vernacularly known as ‘Shisham’ in Hindi, is a deciduous rosewood tree. *Dalbergia* is a large genus of small to medium-size trees, shrubs, and lianas in the Leguminosae family. Shisham is widely distributed in the Indian subcontinent. Its yellowish-brown wood is hard and resistant to cracking, with an aromatic smell.

2. Material and Methodology

The present investigation entitled as “Evaluation of some anatomical features of Shisham wood from Rajasthan” was carried out in the Department of Forest Products & Utilization, College of Horticulture & Forestry, Jhalawar during November 2021 to March 2022. The wood samples of. *D. sissoo* T_1-T_{12} (Shisham) were collected from twelve district locations of Rajasthan Chemical analysis was carried out by employing TAPPI (Technical Association of Pulp and Paper Industry) standard methods.

Table 1. Variation in vessel, fibre length (mm) and fibre diameter (mm) of *D. sissoo*.

Treatment	Location	Value of vessel length (mm)	Value of vessel diameter (mm)	Value of No. of vessels per mm^2	Value of fibre length (mm)	Value of fibre diameter (mm)
T_1	Baran	0.168	0.131	4	0.983	19.960
T_2	Barmer	0.170	0.128	3	0.890	19.953
T_3	Bhilwara	0.178	0.149	6	0.980	20.027
T_4	Bikaner	0.168	0.128	5	0.877	19.950
T_5	Jaipur	0.173	0.132	6	0.897	19.990
T_6	Jhalawar	0.195	0.153	4	1.017	20.237
T_7	Kota	0.186	0.146	2	0.973	20.233
T_8	Nagaur	0.167	0.133	7	0.887	19.870
T_9	Rajsamand	0.162	0.140	6	0.987	20.007
T_{10}	Sikar	0.169	0.150	6	0.877	20.087
T_{11}	Sri Ganganagar	0.168	0.137	6	0.977	20.063
T_{12}	Tonk	0.164	0.145	5	0.993	20.187
SEm		0.002	0.002	0.667	0.028	0.052
$CD_{0.05}$		0.005	0.005	1.376	0.058	0.107

Results and discussion

The data pertaining to vessel length in Shisham wood ranged between 0.162 mm to 0.195 mm in among the locations. The vessel diameter showed significant variation among Shisham wood ranged between 0.128 mm to 0.153 mm among Shisham wood samples from all locations. Karimanisha et al (2020) also reported that in *D. sissoo* there are differences in vessel diameter in the radial part of the wood. Similar results were found by Sunny (2017) in *Dalbergia sissoo.* Numbers of vessels was ranged between2-7 in wood samples in different locations Karimanisha et al (2020) also reported that in *Dalbergia sissoo* there are differences in vessel diameter in the radial part of the wood. The fibre length was ranged between 0.877 mm to 1.017 mm in wood samples in all locations, which is might be due to genetically controlled and not subject to the influence of environmental fluctuations the Sykes et al (2006). The fibre diameter was ranged between 19.870 mm to 20.333 mm in among locations which is might be due to response to decreased water availability David et al (2009).

References

David MD, Geoffrey MD, Anthony PG, Jennifer R and Dale W 2009. High resolution temporal variation in wood properties in irrigated and non-irrigated *Eucalyptus globulus*. Annals of *Forest Science* **66**: 1-10p.

Karimanisha K, Krishnakumar N and Parthiban KT 2020. Wood anatomical properties of *Dalbergia sissoo* Roxb. *Life Sciences Leaflets*, 119: 1-12p.

Sykes R, Li BL, Isik F, Kadla J and Chang HM 2006. Genetic variation and genotype by environment interactions of juvenile wood chemical properties in *Pinus taeda* L. *Annals of Forest Science* **63**(8): 897-90p.

4.35/T_4-147

Coconut Wood: Anatomy and Structural Implications

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Keywords: Coconut, wood, fibre, anatomy

1. Introduction

Coconut (*Cocos nucifera* L.) wood is a durable, eco-friendly alternative to traditional hardwoods. It's harvested from coconut palm trees that have reached the end of their fruit-bearing lifespan. Coconut wood has unique grain patterns and is resistant to rot, insects, and moisture. It is popular for furniture, flooring, and decorative items (Srivaro et al 2020).

2. Material and methods

Coconut wood samples were collected from top, middle and bottom portions of the tree trunk. For each portion core and peripheral samples were collected. Then, the samples were subjected to Microtomy using a Sliding Microtome (Leica SM 2000R) followed by staining. Maceration using Schultz method performed for the analysis of fibre morphology. Image analysis was done using Catymage® image analyzer and data analysis was done using the software R (Version 4.2.2).

3. Results and discussion

Moving from top to bottom of the coconut trunk, the basic density, fibre length as well as strength properties increased. As well as, moving from core to periphery the basic density, fibre length as well as strength properties increased. The corelation analysis showed a positive relation between fibre wall thickness and basic density.

Table 1. Coconut wood anatomical and structural features

Specimen location	Fibre length (μm)	Fibre wall thickness (μm)	Basic density(g/cc)
Top Core	756.63	28.15	0.75
Top Periphery	855.98	33.38	0.79
Middle Core	927.75	32.56	0.85
Middle Periphery	1086.55	35.73	0.98
Bottom Core	1276.47	38.69	1.09
Bottom Periphery	1908.11	45.21	1.22
P Value	> 0.05		

References

Srivaro S, Tomad J, Shi J and Cai J 2020. Characterization of coconut (Cocos nucifera) trunk's properties and evaluation of its suitability to be used as raw material for cross laminated timber production. *Construction and Building Materials* **254:** 119291.

4.36/T_4-152

Current Development and Research in Bamboo in Gujarat State

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Keywords: Bamboo**,** *Dendrocalamus strictus, Bambusa bambos,* agroforestry, tissue culture

1. Introduction

Taxonomically bamboo is a grass belonging to poaceae family and since it has been exempted from forest with the effect of IFA – 1927 amended in 2017, it becomes popular and farmers are enquiring for bamboo farming. Entrepreneurs are also willing to set up the bamboo based industries such as agarbatti stick industries, Charcoal industries, ethanol industries, composite furniture industries etc. Despite of their willingness major challenges in recent time is huge shortage of raw material for running of industries, skilled labour, right choice of species, plant availability, agronomical practices, low shelf life and analysis of different bamboo species for its strength and quality.

2. Materials and methods

Naturally forest of Gujarat state harbor of two bamboo species *viz*. (1.) *Dendrocalamus strictus* (Manvel/Bharat Bamboo) and (2.) *Bambusa bambos* (Kantas Bamboo). Gujarat state has two bamboo germplasm conservation areas *viz*. 1.) Singalkhanch, Tapi Forest Division, Vyara comprises of 26 species and 2.) Bamboo Resource Centre, College of Forestry, NAU, Navsari comprises of 33 species. As per demand and popularity of bamboo it is mandatory to increase bamboo plantation of different species in forest and non forest area for that concern require bamboo planting material which will be fulfilled by bamboo nursery. We are providing right bamboo species planting material to farmers as per their end use of culm, lacunae of skill labour overcome by training programme which we are providing at our Bamboo workshop, low shelf life of bamboo culm mitigate by using preservation and seasoning technique and analysis of different bamboo species for different parameters are using anatomy lab, biotechnology lab and tissue culture lab.

3. Results and discussion

Due to high public demand, popularity and inquiry pertaining to bamboo for plantation and bamboo based industries we have established Bamboo Resource Centre under the beneath College of Forestry, NAU, Navsari. We are working on the different aspects such as bamboo germplasm conservation unit having 33 species, bamboo nursery & propagation, clump management & harvesting, preservation & seasoning, bamboo workshop & products, bamboo based agroforestry model, bamboo tissue culture, biotechnology & anatomy aspects and research pertaining to hurdles' facing by farmer's & need based research. Recently we are working on the bamboo shoot analysis for nutritional value, leaf leachate analysis for allelopathy effect, molecular & anatomy analysis for identification, macro & micro propagation for multiplication bamboo plants. Tissue culture & macro propagation of different bamboo species, growth evaluation of different bamboo species, DNA barcoding of different bamboo species and bamboo leaves nutritional value of different bamboo species research were completed under beneath of BRC.

4.37/T_4-153

Wild Food Resource Utilization in Tribal Communities of South Gujarat

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Keywords: Food, wild, tribe, pods, nuts, mushroom, lifestyle

1. Introduction

Since ancient times, wild food supplements are helpful in maintaining the dietary balance of the tribal communities. Wild plants are a crucial source of food, healthcare and material subsistence in much of the tribal communities and carry a strong association with their ethnic culture. Wild edibles continue to be a preferred food in much of the tribal communities. A consensus has now been formed that information on wild edibles is an important part of ethnobotanical knowledge. Elucidating patterns of ethnic food culture will help in developing the conservation strategies for those wild resources. With this background, present study was conducted to document the collective knowledge of wild edibles possessed by selected ethnic communities of south Gujarat.

2. Material and methods

Information on the utilization pattern of wild edibles were collected through Participatory Rural Appraisal (PRA) method. Data collected from 100 respondents and they were mainly from Dhodia, Kukna, Varli, Gamit and Naika communities of south Gujarat region. Expert interviews with key informants were also conducted to know past and present consumption trends.

Table 1. List of wild food sources utilized by the communities

Sr. No.	Type of food resources	Number of species	Sr. No.	Type of food resources	Number of species
1	Fruit trees	23	5	Tubers	01
2	Green leafy vegetables	09	6	Tree Seeds	01
3	Wild flowers	03	7	Mushroom	03
4	Bulb	01	8	Young shoot	02

3. Result and discussion

It was found that, 40 species of wild food plants belong to 21 families were commonly consumed by the local communities of south Gujarat region namely, Dhodia, Kukna, Varli, Gamit and Naika. The various wild food sources recorded are tree-based food, tuber crops, leafy vegetables, fruit crops, bulb, pods, seeds, nuts, mushroom (Table 1). Study revealed that, in recent days, ethnic food culture is declining due to many reasons like unavailability, deforestation, over-harvesting, indiscriminate way of utilization, change in food preference and modern lifestyle. These factors eventually leading to resource degradation as well. This study generated the baseline data helpful for prioritization of conservation strategies helpful for sustainable utilization and management of these resources. Community based conservation efforts will be more effective way for resource management and maintaining the ethic food culture of the communities in long run.

Reference

Chauhan SH, Yadav S, Takahashi T, Luczaj L, Cruz LD and Okada K 2018. Consumption patterns of wild edibles by the Vasavas: A case study from Gujarat, India. *Journal of Ethnobiology and Ethnomedicine*, **14** (57).

4.38/T_4-156

Rudiments of Sustainable Bark Harvesting in Medicinal Trees

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Keywords: Bark**,** medicinal tree, sustainable harvesting, over exploitation, regeneration

1. Introduction

Medicinal plants play an important role in health care system especially in developing countries. The forest in India is the principal repository of large number of medicinal and aromatic plants, which are largely collected as raw material for manufacturing drugs, perfumery and other edible products. Bark is one of the most utilized plant parts constituting major component for the preparation of various formulations in the Indian system of medicine. The growing demand for medicinal bark, commercialization and destructive harvest techniques pose a major threat to high demand forest species. Also, a huge population, especially rural communities, still use traditional medicines mostly harvested from natural forests. Considering the importance of the medicinal plant industry and the dependence of communities on traditional medicines is growing concern, as it is leading to uncontrolled, destructive harvesting and over exploitation of tree bark from natural forests. Such practices have been dragging many valuable tree species towards extinction.

2. Material and methods

Literatures related to harvesting of bark, their impact on trees and sustainable bark harvesting practices were reviewed. Relevant literatures focusing on said areas were collected, reviewed properly and presented to highlight the importance of sustainable bark harvesting especially in medicinal trees with special reference to tropical species.

3. Results and discussion

Bark harvesting can be injurious and dangerous to the survival of trees if indiscriminately practiced. Therefore, it is necessary that the harvesting practices employed should be non-destructive. Systems for sustainable bark harvesting largely depend on the response of the target species to bark stripping. The volume of bark that could be harvested under different harvest prescriptions and scenarios would largely depend on the growing stock and growth of the target species, bark characteristics (especially bark thickness) and the rate of bark regrowth after harvesting. Overall, review shows that bark of many woody plants having various medicinal properties and utilized in larger scale by herbal industries. Study also indicating that, the quality of bark in terms of its biomass, chemical properties, regrowth/healing properties are depending upon several factors like species, genotypes (individuals), age or girth of trees, season of collection, parts used (main stem/branches), methods of bark harvesting/collection made including processing and storage. Different tree species react differently to bark harvesting both in terms of wound closure and susceptibility to insect and fungal attack. It is observed that, vertical strip method of bark harvesting with one or two collection frequency is ideal for bark yielding medicinal trees which may regenerate/recovery the bark without causing much damage to the trees. Strip harvesting also helpful to ensure a sustainable supply of medicinal bark to the needy stakeholders. Literatures also suggested the application of protection treatment (eg. fungicide) immediately after the bark harvesting not only act as protection function, but also improve the bark regeneration.

Reference

Pandey AK, Yadav S and Sahu SK 2011. Sustainable bark harvesting and phytochemical evaluation of alternative plant parts in *Holarrhena antidysenterica* R. Br. Sans (Kutaj). *Int. J. Green. Pharm.***5**:107-112.

4.39/T_4-157

Color Extraction from *Butea monosperma* (Palash) flowers

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Keywords: *Butea monosperma* flower, color, solvent extraction

1. Introduction

Butea Monosperma belongs to family *Fabaceae* and also called "*the flame of the forest*" due to bright orange and scarlet colors flowers. Compounds like; lanceoletin, butein, monospermoside and sulfurein have been isolated from the flower petals which could be utilized as cosmetic. It has got immense potential for use as herbal color, which shall create an additional income to tribe. In traditional methods, the time of color extraction using water was found to be long with less recovery and poor-quality extract.

2. Material and methods

An experiment was conducted using steeping method of extraction at four temperature conditions with six treatments; T_1:Normal tap-water, T_2:RO-water, T_3:Methanol (100%), T_4:Methanol (50%), T_5:Ethanol(100%) and T_6:Ethanol(50%) to extract the color from cleaned *B. monosperma* flower petal till the its color disappear. After removing the colorless petal, dry dye was separated from solution using soxhlet method followed by dye drying at 45ºC. The dye color content in dry dye was estimated using colorimetric method using standard dye solution of saffron colour tatrezine.

3. Results and discussion

The results of dry dye recovery, dye color content and extraction time, indicated in table-1. It indicated that, the 50% v/v methanol solvent (Treatment-T_4) has recovered highest dry dye of 0.310g per 100g flower and dye color content of 179.25ppm as tatrezine compared to other treatments consistently with considerable extraction time of 22h 45 min in steep solvent extraction method. Further with 50%v/v methanol solvent for colour extraction process, as the seeping time as well as temperature of steeping solution increased, the dye content increase. The highest dye content was observed with 60ºC steeping solution temperature and 4h time of steeping. It is recommended to use 50%v/v methanol for colour extraction from cleaned *B. monosperma* flower petal for 4h in steeping solvent extraction process.

Table 1. Effect of various solvents on color extraction of *B. monosperma* flower

Treatment	Extraction Time, (h)	Dry Dye Recovery, (%)	Dye content, (ppm)
T1	35.13	0.279	110.135
T2	34.75	0.273	119.625
T3	21.63	0.284	139.475
T4	22.75	0.310	179.25
T5	23.75	0.278	125.363
T6	25.38	0.279	163.95
Mean	27.23	0.284	139.633
SEm ±	0.84	0.012	1.688
CD at 5%	0.21	0.003	0.61
CV %	6.16	7.19	2.41

4.40/T_4-177

Variation in Proximate Principles of *Melia dubia* Fodder across Different Sources of Gujarat, India

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Keywords: *Melia dubia*, leaf fodder, proximate principles, nutritive value, livestock

1. Introduction

Numerous tree species have been evaluated for their leaf fodder and pod feed quality and has been promoted to reduce feed costs by replacing the concentrates. *M. dubia* is being advocated as good alternate fodder species. It has been reported that its drupes can be fed to live stock (Sukhadiya et al 2019, 2022). However, in Gujarat it is not evaluated for its leaf fodder nutritional quality. The study was carried out to assess variation in *M. dubia* leaf fodder nutritional composition of different provenances of south Gujarat**.**

2. Material and methods

Representative leaves samples were collected from different provenances of south Gujarat. Oven dried samples were analyzed for its proximate attributes, minerals matter and cell wall composition as per procedure given by AOAC (2016).

3. Results and discussion

The study revealed substantial variations (p<0.05), in proximate principles in *M. dubia* leaf fodder across 5 sampled sites in Gujarat. Nitrogen (N), crude protein (CP), ether extract (EE) and crude fibre (CF) content was significantly maximum at site-5 (Dinbari) with respective values of 1.62, 10.14, 3.23 and 16.81 per cent, respectively. The maximum (15.68%) ash content (AC) was determined in leaf samples collected fromsite-2 (Nanapondha). Conversely, highest OM (87.53%) was recorded from site-3 (Mahal). Acid in soluble ash (AIA) was recorded maximum (1.27%) at site-4 (Mulchond). Leaf nitrogen free extract (NFE) was highest (29.83%) at site-1 (Navsari). Lowest NFE (57.28%) was recorded in samples collected from site-5 (Dinbari). The hierarchical cluster analysis indicated that among all the five sites, site-5 looking to be diverse in term of proximate principles of leaf fodder than others. Hence, this population may be used for further selection and improvement.

References

AOAC 2016. "*Official Methods of Analysis"*. 20thEdn. Association of Official Analytical Chemists. Arlington, VA, USA. pp.3172.

Sukhadiya ML, Thakur NS, Gunaga RP, Patel VR, Bhuva DC and Singh S 2019. *Melia dubia* Cav. drupe pulp: a new alternate livestock feed resource. *Range Management and Agroforestry* 40(2): 299-305.

Sukhadiya ML, Thakur NS, Patel VR, Gunaga RP, Kharadi VB, Tyagi KK and Singh S 2022. Provenance variations in proximate principles, mineral matter, total phenols and phytochemicals of *Melia dubia* drupes: an unexplored alternate livestock feed stock. *Journal of Forestry Research* **17**: 119-131.

4.41/T_4-179

Experience with Experiential Learning Programme on Beekeeping

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Keywords: Apiculture, *Tetragonula laeviceps, Apis cerana,* beeflora, pollen, nectar, honey

1. Introduction

Beekeeping is very potential enterprise which can give good employment and income to large number of people. While doing beekeeping one can develop many skills and acquaint oneself with the real economic conditions that are prevalent in the current market system. Keeping all these ideas on the focus and to educate students, farmers and entrepreneurs about the practical aspects of beekeeping, an experiential learning programme (ELP) on beekeeping was started.

2. Material and methods

ELP was started at department of Forest Products and Utilization at College of Forestry, Navsari Agricultural University in the year 2011. In this unit, students get exposure to various activities of honeybee rearing and management; simultaneously, faculty members are engaged in the research on various aspects of beekeeping. The research aspects covered are bee flora survey, important floral plant during the dearth period, habitat study of stingless bees, foraging behavior of stingless bees and pollen study. Besides, market study was also carried out for knowing the honey consumption pattern among the consumers. Moreover, many research works are going on for further strengthening beekeeping in South Gujarat in general and ELP in particular. Among them, some of the important ongoing researches are evaluation of different floral honeys, market study of bee products mainly honey, self life of honey, *etc*. Further, many farmers and entrepreneurs were benefited through training and other services by ELP facilities.

3. Results and discussion

In the beeflora survey during the dearth period of July and August it was found that *Apis cerana* and *Apis mellifera* visited 25 numbers of plant species including climbers, herbs, shrubs and tree species for the collection of nectar and pollen. Out of these plant species most frequently visit was found on nine plant species namely *Vitex negundo*, *Hamelia patens*, *Calliandra* spp., *Cocos nucifera*, *Tamarindus indica*, *Acacia auriculiformis*, *Acacia catechu*, *Samanea saman* and *Anthocephalus cadamba*. In the stingless bee foraging study, the more activities of bees have been recorded during summer season as compared to winter and rainy seasons indicating stingless bees prefers high temperature for more activities that ultimately influence on pollination and storage of honey gathering. The habitat study of stingless bees indicated that there is lot of variation in the nesting habitat and nest architecture of stingless bees (*Tetragonula laeviceps*) in South Gujarat. The maximum number of colonies observed in a particular place was 11 colonies. Database for pollen identification was generated for about 50 different bee floral plants based on size, shape and structure of pollen. The potential and constraints in marketing of honey was identified. The ELP on beekeeping helps the students, farmers and entrepreneurs to enhance their entrepreneurship skills which simultaneously generate the income. Further, the ELP on beekeeping helps to generate research database of different aspects of beekeeping.

4.42/T_4-181

Development of Chironji nut (*Buchanania lanzan*) Grader cum Decorticator

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Keywords*:* Chironji, decorticator, grader, value addition, whole kernel, capacity, efficiency

1. Introduction

Buchanania lanzan (chironji) is a tree species which belongs to the family Anacardiaceae and is commercially very useful. It is originated in the Indian sub-continent and is found growing naturally as wild stand in the tropical deciduous forests of north, western and central India mostly in the states of Madhya Pradesh, Bihar, Orissa, Andhra Pradesh, Chhattisgarh, Jharkhand, Gujarat, Karnataka, Varanasi, Rajasthan, Maharashtra and Uttar Pradesh. Chironji kernels have great medicinal values. The whole kernel is used in sweets, meats, expectorant and tonic. Chironji kernels contain 52% oil and are used for treating skin diseases and it is also considered as a substitute for almond oil in traditional medicinal preparations. They are rich in nutrients and are an active source of crude protein, crude fat, carbohydrates, crude fiber and other rich nutrients like phenolics, natural antioxidants, fatty acids and minerals.

2. Materials and methods

There is excessive loss due to crude methodology adopted for the processing, which leads not only to huge economical loss but also loss of nutrition also. Traditional processing method of chironji is very cumbersome, time consuming and labour extensive and thus it becomes difficult to get labour for this operation. Thus, in order to get good recovery of chironji kernels, the processing cost becomes higher. Thus, a mechanism was developed to reduce processing time, recovery of whole kernel, economical and labour friendly. The efforts were made to develop a PDKV Chironji nut Grader cum Decorticator machine which consist for grading hopper, decortication hopper, sieve assembly, outlets, and motor. The optimized experimental design and performance evaluation of Grading unit (39 experiments) and Decortication unit (29 experiments) of Chironji nut Grader cum Decorticator were generated through Box-Behnken Design and the experimental data was analyzed by applying Response Surface Methodology (RSM) using Design Expert 12.0.8.0 software.

3. Results and discussion

The experimental trials were conducted to optimize the input parameters and evaluated the performance. The developed PDKV Chironji nut Grader cum Decorticator which consisted of grading unit and sieve unit was operated with optimum value of 700 rpm as oscillating speed of sieve assembly, 180 kg/h as feed rate and sieve set of three sieves viz. dia. 9 mm (T), dia. 7mm (M) and dia. 5mm (B) for obtaining maximum grading efficiency of 98.81 per cent. The developed PDKV Chironji nut Grader cum Decorticator which consisted of decortication unit and sieve unit was operated with optimum value of moisture content as 8% wb, feed rate as 80kg/h, speed of disc as 750 rpm and clearance between pair of stone disc as 8 mm for maximum coefficient of decortication - 92.89 %, coefficient of wholeness of kernel - 0.83, decortication efficiency - 76.87 % and capacity of decorticator 22.16 kg/h. The sieve set used was 6 mm diameter round hole (top sieve), 20 x 4 mm slotted hole (middle sieve) and 20 x 2 mm slotted hole (bottom sieve). The average values of protein content for fresh, experimental and commercial kernels were 18.96 %, 18.83 % and 18.24%. The average values of fat content for fresh, experimental and commercial kernels were 39.40 %, 38.20 % and 41.2%. The average values of overall acceptability for sensory evaluation of experimental and commercial kernels. The average values of colour for fresh, experimental and commercial kernels were L* as 52.67, 5.55 & 9.46, value of a* as 55.47, 6.59 & 11.46 and value of b* as 56.67, 7.31, 13.03. The average values of water activity (aw) for fresh, experimental and commercial kernels at 33^{o} C were 0.584, 0.248 and 0.343.

Plate 1. *B. lanzan* nut Grader cum Decorticator

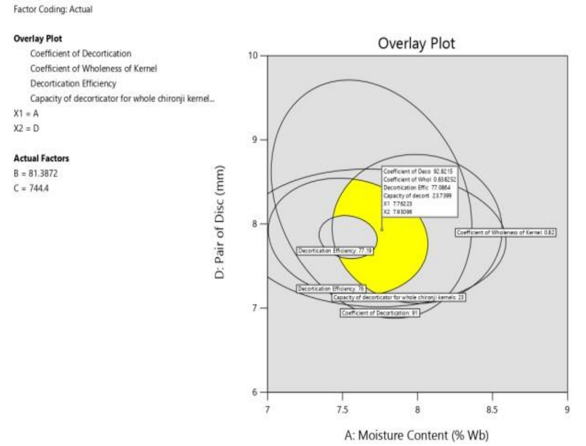

Fig. 1. Effect of moisture content (MC) and clearance between pair of disc (POD) on various responses

The chironji nut grader cum decorticator machine is economically viable with annual net profit of Rs. 1,36,0196, benefit cost ratio 13.54 % and cost of decortication Rs. 3.50 per kilogram. The developed assures the safety of the operator. The mechanism was portable, thus, would be easily shifted / transported from one place to another. Even an unskilled labour was able to operate the developed decorticator. The easy mechanism helps to reduce the processing cost and maintenance cost. The developed chironji nut decortication would help the cooperative farmers, tribal people, small help groups (SHG) and unemployed youths to become an entrepreneur.

4.3/T_4-182

Innovative Technology for preparing Value added product from *Mucuna pruriens*

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Keywords *: Mucuna pruriens,* value addition, process, drying, powder recovery

1. Introduction

The plant *Mucuna Pruriens* belongs to family "*Fabaceae*". It is widely known as "velvet bean" and mostly found in the form of a vigorous annual climber. It is originally from Southern China and Eastern India. It is considered as a viable source of dietary proteins due to its high nutritional value. The research work entitled "Innovative Technology for preparing Value added product from *M. Pruriens"* was carried out at department of Agricultural Process Engineering, College of Agril. Engg. and Technology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and the Mucuna seeds were procured from Medicinal department of Nagarjun, Dr. P.D.K.V., Akola. The research work was carried out in order to increase the awareness among the community about its medicinal benefits and also to make *M. Pruriens* available in powder form.

2. Materials and methods

The various process parameters like soaking (h), boiling (min), autoclaving (min) and drying (°C) were optimized for maximum powder recovery (%) and minimum powder loss (%) of *M. pruriens*. The process parameters for the preparation of Mucuna seeds powder were analyzed by Response Surface Methodology (RSM) using Design - Expert software (version 11.1.2.0). Based on the preliminary experiments, Box Behnken design was finalized for conducting 29 experiments with three level and four factor. The cleaned Mucuna seeds of 200g were used for each experiment.

Plate1. *Mucuna pruriens* seed and powder

3. Results and discussion

The effect of soaking (6, 9 and 12h), boiling (20, 30 and 40 min), autoclaving (10, 20 and 30 min) and drying (40, 50 and 60°C) were studied and the range for various responses were observed *viz.*, recovery of powder (74-87%) and loss of powder (13-26%). As per graphical optimization technique, the superimposed contours showed the optimized values for soaking, boiling, autoclaving, and drying as 9h, 30min, 20 min and 50°C for obtaining responses as 87% recovery of powder and 13% powder loss. The average values of colour L*, a* and b* for raw sample were 74.51(±4.19), 0.59 (±0.03) and 12.49 (±0.91) and for optimized sample the values were 71.34 (±4.20), 0.56 (±0.01) and 10.93 (±0.46). The average values of water activity (a_w) for raw and optimized sample at 33°C were 0.57 (±0.02) and 0.34 (±0.008). The average values of protein content (%) for raw and optimized sample were 18.96 (± 0.32) and 18.24 (± 0.43%). Also, the average values of L-Dopa content (g $100g^{-1}$) for raw and optimized sample were 4.79 (±0.40) and 1.09 (±0.26) g $100g^{-1}$.

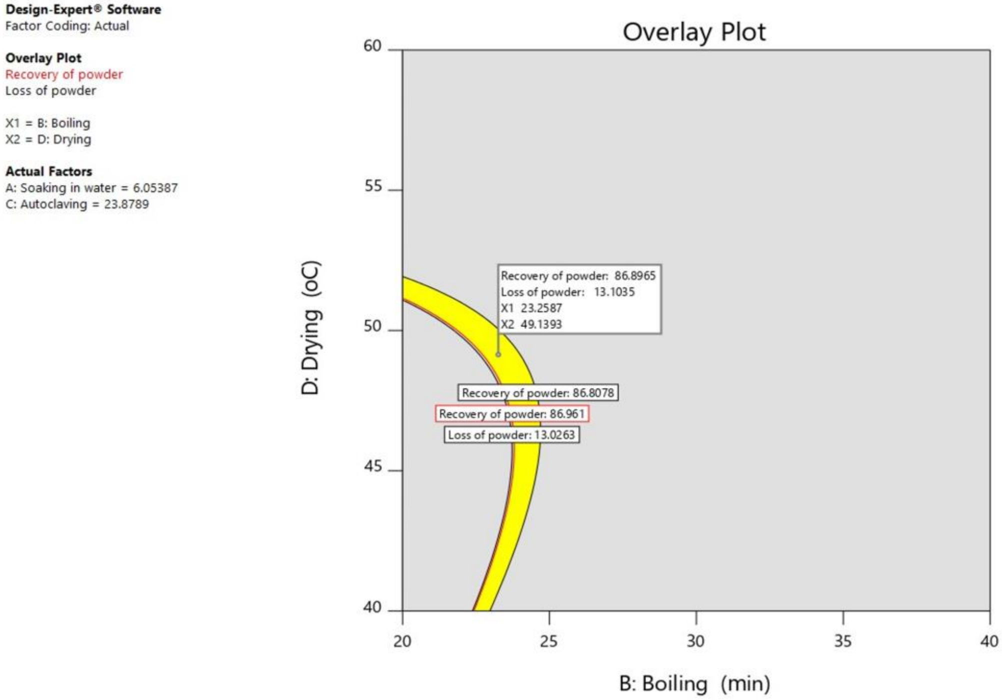

Fig. 1. Effect of boiling (B) and drying (D) parameters on responses

The average values for sensory attributes of raw sample and optimized sample were colour 7.4(±0.52) and 7.5 (±0.53), taste 7.0 (± 0.47) and 6.7(± 0.48), texture 7.6 (± 0.52) and 7.5 (± 0.53), appearance 7.5 (± 0.53) and 7.2(± 0.63) and average overall acceptability 7.4(± 0.52) and 7.2(± 0.63). The Cost economics for preparing powder from Mucuna seeds was estimated and the annual net profit gained was calculated as Rs. 2,24,896, the cost benefit ratio was 1.16, the payback period was 0.32, the return on investment was 84.96%, the employment generation was 120 man-days. The prepared *M. Pruriens* powder is a ready to eat value added product hence could be used for consumption by adding to liquids, milk, salads, curries, etc. The developed process technology for preparing *M. Pruriens* powder may be adapted by small, medium and large scale farmers, self help groups (SHG), unemployed youths to become an entrepreneur.

4.44/T_4-186

Effect on Physical and Mechanical Properties of Thermally Modified *Bombax ceiba* L. Wood

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Keywords: *Bombax ceiba,* wood properties, specific gravity, moisture content

1. Introduction

Bombax ceiba L. commonly known as Semal is a deciduous tree belonging to the family Bombacaceae. The timber is of light weight and is used for manufacture of match boxes and splints, veneers, plywood, coffins, artifact production etc. (Griffiths et al 2003). Tree reaches up to 40 m in height and 6 m in girth, with the clear bole of 20-30 m. It is widely distributed in Indian subcontinent except in extremely arid regions ascending up to 1200 m and occasionally up to 1500 m. Though typical of the alluvial savanna type of forest, it grows sporadically in mixed deciduous forests in the sub Himalayan regions and even in Sal forests.

2. Material and methods

The wood of the *B. ceiba* collected from the market was converted into required dimensions as per the test specifications. The samples were planed and sanded for maintaining the smoothness. Heat treatment of wood was carried out at 80, 120, 160 and 200°C for 2, 4 and 6 hours. The Maximum Moisture Content method was used to determine the specific gravity and the mechanical properties of wood were determined as per the procedure followed for testing in Universal Testing Machine (Model:UTN-10).

Table 1. Physical and mechanical properties of thermally modified wood of *B. ceiba*

Heat treatment	Duration (H)	Specific gravity	Moisture content (%)	Tensile strength (kN/mm^2)
Untreated control		0.422	23.86	0.044
	2	0.415	21.37	0.046
80°C	4	0.408	18.21	0.043
	6	0.406	16.84	0.039
	2	0.403	8.65	0.041
120°C	4	0.399	7.72	0.043
	6	0.394	5.70	0.041
	2	0.382	2.74	0.042
160°C	4	0.383	1.93	0.040
	6	0.378	1.59	0.038
	2	0.373	1.28	0.040
200°C	4	0.367	1.01	0.039
	6	0.364	0.73	0.032

3. Results and discussion

From Table 1 it is concluded that the specific gravity determines the strength of wood. The maximum specific gravity (0.422) was recorded in control which was statistically at par with 80°C (0.410) and at 120°C (0.399). The minimum value (0.368) for specific gravity was noticed at 200°C, which was statistically at par with the value (0.381) obtained at 160°C. The maximum moisture content of 23.86 per cent was observed in control, whereas minimum value of moisture content (1.01%) was recorded at 200°C.

The tensile strength was recorded to be maximum (0.044 kN/mm^2) in control which was statistically at par with 80°C (0.043 kN/mm^2) and at 120°C (0.042 kN/mm^2). The minimum value of 0.037 kN/mm^2 was noticed at 200°C. According to Schneid et al (2014), the wood of *Luehea divaricata* has shown slight reduction in specific gravity with increase in temperature. Gunduz and Aydemir (2009) also found decrease of equilibrium moisture content in *Carpinus betulusinus* wood after thermal treatment at 170-210°C for 4-12h. Boonstra et al (2007) has reported a clear effect on mechanical properties of thermally modified softwood species, where tensile strength parallel to grain has shown decrease in value as compare to control after heat treatment.

References

Boonstra MJ, Acker JV, Tjeerdsma BF and Kegel EV 2007. Strength properties of thermally modified softwoods and its relation to polymeric structural wood constituents. *Annals of Forest Science, Springer Verlag/EDP Sciences* **64**:679-690.

Schneid E, Cademartori PHG and Gatto D 2014. The effect of thermal treatment on physical and mechanical properties of *Luehea divaricata* hardwood. *Maderas. Ciencia y tecnología* **16**:413-422.

Gunduz G and Aydemir D 2009. Some Physical Properties of Heat-Treated Hornbeam (*Carpinus betulus* L.) Wood. *Drying Technology* **27**:714-720.

Griffiths AD, Phillips A and Godjawa C. 2003. Harvest of *Bombax ceiba* for the aboriginal arts industry, Central Arnhern Land, Australia. *Biological Conservation* **113**:295-305

4.44/T_4-188

Wood properties and utilization of pollard shoots of Indian tulip tree (*Thespesia populnea* (L.) Sol. ex Corrêa)

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Keyword: Static bending, compressive strength, volumetric shrinkage, hardness, wood density

1. Introduction

Forests are declining in India under severe socio-economic pressure (Saravanan et al 2014). Consequently, short-rotation plantation wood species are emerging as a major raw material resource because of ban on tree felling in the forests (Sujatha et al 2023). Due to shortage of raw materials, industries have to establish the short-rotation fast-grown plantations of suitable wood species. Furthermore, there is also a need to explore the wood properties of lesser-known tree species for various end use applications. Indian tulip tree (*Thespesia populnea* (L.) Sol. ex Corrêa) is one of the fast growing lesser-known tree species which is heavily pollarded and its shoots are used as fuelwood in coastal regions of South Gujarat. Since, *T. populnea* has potential for timber, pulpwood and other industrial applications; therefore, a study was carried out to evaluate the physical and mechanical properties of pollard shoots of this species to check the wood quality for effective utilization.

2. Material and methods

Total 20 wood samples of pollard shoots (5-10 cm diameter) from 5 trees of *T. populnea* in the girth class of 110-160 cm were collected from the different blocks of Matwad road side plantation in Navsari, Gujarat for the present study. The physical properties *i.e*., moisture content, basic density, volumetric shrinkage and mechanical properties *i.e*., static bending, compression parallel and perpendicular to the grain, hardness and nail & screw holding test of the species were evaluated in air-dry condition at 15.9% moisture content and compared them with published values for teak (*Tectona grandis* L.f.) and 3, 4 & 5 years old Malabar neem (*Melia dubia* Cav.).The moisture content and volumetric shrinkage were determined by oven-dry method, while basic density was determined by water displacement method. The mechanical properties of wood were tested using the Universal Testing Machine (UTM).

3. Results and discussion

The mean basic density and volumetric shrinkage based on oven-dry weight of wood samples from pollard shoots of *T. populnea* were 0.249 g/cm^3 and 47.0 %, respectively. In comparison with teak and *M. dubia*, wood density of *T. populnea* recorded 37 per cent value of teak wood density and 50 per cent value of *M. dubia* wood density, while volumetric shrinkage of this species was seven times more than teak and three times more than Malabar neem. Very low wood density and high volumetric shrinkage in *T. populnea* may be due to the thin diameter of juvenile wood of pollard shoots. The mean value of MOR (modulus of rupture) and MOE (modulus of elasticity) in static bending were 786.8 kg/cm^2 and 72.6 x10^3 kg/cm2, respectively. In compressive strength parallel to grain, the mean value of maximum crushing stress was 358.3 kg/cm^2 and in compressive strength perpendicular to grain, the mean value of compressive stress at elastic limit was 33.3 kg/cm^2. The mean value of side and end hardness were 444.2 kg and 490.6 kg, respectively. The mean value of nail holding power on side and end surfaces were 42.3 kg and 32.3 kg while, screw holding power on side and end surfaces were 60.4 kg and 50.5 kg, respectively. It is concluded that the physical properties and mechanical strength of wood from pollard shoots of *T. populnea* is lower than teak wood. Among mechanical properties, static bending, compressive strength and hardness of wood from pollard shoots of *T. populnea* are found to be better than 3 years old *M. dubia*. This indicates that wood from pollard shoots of thin to moderately thick diameter of this tree species can be utilized for tool handles, construction, light packing cases and furniture.

References

Saravanan V, Parthiban KT, Thirunirai R, Kumar P, Vennila S and Kanna S U 2014. Comparative study of wood physical and mechanical properties of *Melia dubia. Research Journal of Recent Sciences* **3**(ISC-2013): 256-263.

Sujata M, Shivaprasad HC and Shukla SR 2023. Wood properties and utilization of a few important tree species grown in agroforestry in India. *Wood is good* **3**(2): 91-99.

5.1/T_5-14

Stand Structure and Species Composition of Community Forests under Livelihood Transition in Two Villages in the Inle Lake Region, Myanmar

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Keywords: forest transition, community-managed forest, disturbance, harvesting methods, NTFPs

1. Introduction

Nearly one third of tropical forests are now in the hands of local people. Varying local livelihoods in a different landscape may differ the species composition, diversity, and stand structure of forest conditions. This study observed the stand structure and species composition of community managed forests in two villages in the Inle lake region, Shan State of Myanmar.

2. Material and methods

A total of 44 circular plots were established to sample trees ≥ 5cm diameter (DBH) (1.38 ha). Focus group discussion and key informants are conducted to know the history of forest utilization in the past and livelihood transition. Importance value index (IVI) was calculated based on relative abundance, relative density, and relative dominance. Abundance (ha $^{-1}$), basal Area(m^2/ha) of each species were calculated. Regression analysis of normal and coppice trees were conducted to know forest recovery condition.

3. Results and discussion

Fifty-one species in thirty families were recorded. *Dipterocarpus tuberculatus, Shorea siamensis, Quercus brandisana, Melanohorrea usitata*, and *Xylia xylocarpa* were the most important species in these community forests and accounted for about 73.17% of all recorded stems ≥ 5cm DBH. The site had a long history of fuelwood collection for local and regional needs until 2010. The presences of coppice and pollard trees are indicative of past disturbance activities. Dependency on the community forest resource was reduced after the electrification of the area, a marked shift to tourism-related livelihoods, stabilized transportation access to the agricultural market. It can be concluded that livelihood transitions facilitated less dependency on forest resources and supported community forest regeneration.

5.2/T_5-31

Diversity of Trees at Navsari Agricultural University Campus: Pictorial Glimpses

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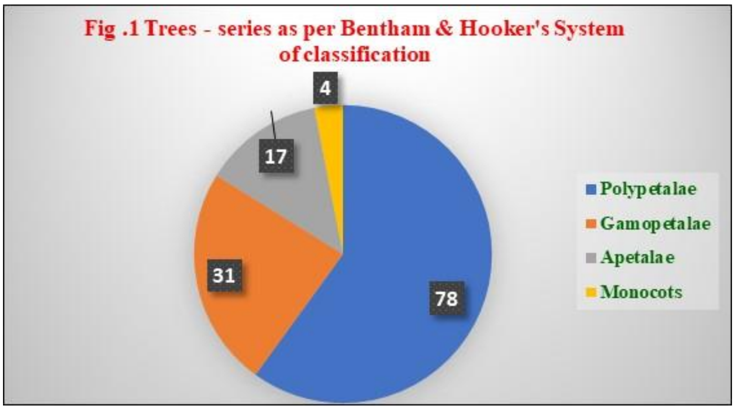
Keyword: Diversity, trees, polypetalae, gamopetalae

1. Introduction

Taxonomy, in a broad sense the science of classification, but more strictly the classification of living and extinct organisms *i.e.*, biological classification. The term is derived from the Greek taxis (“arrangement”) and nomos (“law”). Taxonomy is therefore, the methodology and principles of systematic botany and zoology and sets up arrangements of the kinds of plants and animals in hierarchies of superior and subordinate groups. It has become a synthetic science that benefits from research in a very wide range of subjects both in the organic and inorganic world.

2. Material and methods

Trees were arranged both alphabetic as well as Bentham and Hooker’s System of classification. With respect to nomenclature of trees, APG-VI nomenclature codes were followed. Hence, this manuscript deals with Digital photographs of tree species enumerated during the Dissertation work at Navsari Agricultural University. “Look Alike Species” that have thin line of difference in morphological characters are included with precise photographic evidences, e.g. *Crateva religiosa* DC. Subsp. *odora* (Buch. Ham) Jacobs and *Aegle marmelos* (L.) Correa.



3. Results and discussion

A preliminary survey of NAU Campus during the period of 2021-22 accounted to total of 131 tree species, which are classified according to widely accepted Bentham and Hooker’s system of classification. References of Sigh and Gavali (2008) and Swaminathan and Kochhar (2019) referred for botanical descriptions. Out of 131 spp., 78 spp. belongs to class Polypetalae, 31 spp. of Gamopetalae and 18 spp. of Apetalae. 127 spp. are Dicots, whereas 04 monocots forms 131 spp. Dicot accounts to 96% of total tree flora. 68 trees have simple leaves out of which 45 spp. have alternate phyllotaxy and 23 spp. have opposite. 63 spp. have compound leaves, further distributed via. (28 spp.) have Unipinnate leaves, (11 spp.)-Bipinnate leaves (2 spp.)-Tripinnate leaves, (5 spp.)-Trifoliate leaves, (10 spp.)-Multifoliate leaves followed by (3 spp.) with Palmate leaves respectively. In context to Bark features, (110 spp.) have rough bark, whereas (21 spp.) have Smooth Bark. Phenological observations resulted in (60 spp.) exhibiting fruiting condition and (44 spp.) in flowering condition.

References

Singh HS and Gavali JG 2008. “*Trees of Gujarat*”. Gujarat Forest Department, Gandhinagar.
Swaminathan MS and Kochhar SL 2019. “*Major Flowering Trees of Tropical Gardens*”. Cambridge University Press, Cambridge, United Kingdom. pp. 1-380.

5.3/T_5-34

Determining Factors of People's Participation in the Community Forest (CF) Program in the Central Dry Zone (CDZ) During the Rural Livelihood Transition in Myanmar

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Keywords: Community forest, rural livelihood, migration, people participation

1. Introduction

Community Forest (CF) program has been used globally to protect forests and enhance local people's livelihoods (Gilmour 2016). In Myanmar, the CF program was introduced in 1995. As of January 2021, more than six thousand CFUGs with a total area of 352,163 ha (870,215 acres) of state-owned forest have been transferred to local people to manage and get the benefits of the forest. Although the area of CF has significantly increased over the last decade, the weakness of local people's participation in the CF program is one of the policy challenges for the government of Myanmar. This paper explores the relationship between local people's participation in the CF program and the socioeconomic characteristics of households during the livelihood transition in the CDZ.

2. Material and methods

A semi-structured questionnaire, a key informant interview, and a focus group discussion were used for primary data collection. A structural interview with 189 households was conducted from December 2021 to March 2022 through stratified random sampling to get quantitative data on socioeconomic data, natural resources ownership, awareness of CF, and participation in the collective activities of CF. For statistical analysis, we used SPSS 28.0.0.0. In model 1, the binary logistic regression was deployed to examine factors of local people's decision to participate in the CF program. Then, Model 2 explores factors affecting people's participation times in collective activities through multiple linear regression.

3. Results and discussion

According to model 1, among ten independent socioeconomic variables of local people, seven factors are determining that influence local people's decision to participate in the CF program, which are gender of household head, availability of family labor, agricultural land holding size of household, livestock holding unit of household, customary forest area, education of the household, and non-farm income of the household. As per model 2, three independent characteristics of CF member households have influenced CF member participation in the CF program's collective activities: the non-farm income of the CF member's household, working outside of the township area, and availability of family labor. This study confirms that local people’s interest in participating in the CF program is strongly influenced by changes in rural livelihood, particularly increasing non-farm income of the household with the popularity of migration in the CDZ.

Reference

Gilmour D 2016. Forty years of community-based forestry: A review of its extent and effectiveness. *FAO forestry paper* (176).

5.4/T_5-36

Ethnomedicinal Knowledge and Role of Tribals in Conservation, Sustainable Management and Ecotourism in Anamalai Biosphere Reserve, Tamil Nadu, India

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Keywords: Indigenous Traditional Knowledge, Ethnomedicine, ecotourism, biosphere

1. Introduction

Anamalais Biodiversity Hotspots, situated in Western Ghats, India is unique in biodiversity, culture, and ethnic traditions; holds more than 6889 tribals population of 6 tribes *viz*., Kadar, Muduvar, Malasar, Malai malasar, Eravalar and Pulayar differ in their culture and traditions (Chandi 2008). Tribes nurture Indigenous Traditional Knowledge (ITK) invariably play important role in conservation, sustainable management, and ecotourism.

2. Material and methods

Total 300 individuals (50 in each tribe) were interviewed using a proportionate random sampling method from 35 settlements based on a questionnaire survey. Ethnomedicinal data was documented based on local/botanical name, plant part used, ailment, and mode of treatment (Revathi and Parimelazhagan 2010). Roles of tribals in conservation, sustainable management, and ecotourism were examined with scoring (yes =2 and no=1).

3. Results and discussion

For 36 ailments, 15 parts of 69 ethnomedicinal plants of 17 families were documented. Conservation of natural forest, tribals played outstanding role with more than 98%. Conservation of wildlife 90%, ITK and cultural practices 100% of Muduvar tribe; forest plantation and natural resources 100% of Pulayar tribes plays an outstanding role. Muduvar tribe with top of 227 score attributed greater role in sustainable management i.e., natural resources/NTFP, natural calamities, disaster/fire control and plantation activity by formation of Vanakulu/Vanaurumaikulu with cooperation of Tribals and Forest Department in all tribes.100% Eravalar tribe preferred ecotourism whereas Muduvar tribe had zero participation. Additional investigation is obligatory to explore such ITK. Necessary steps are required to foster less participated tribals role in conservation, sustainable management and ecotourism.

Table 1. Role of tribals in sustainable management of forest in Anamalai Biosphere Reserve,T.N.

Sustainable management status	Kadar	Muduvar	Malasar	Malai malasar	Eravalar	Pulayar
Availability of JFMC in village	21	21	7	0	50	42
Member of JFMC committee	11	15	4	0	11	30
Play a role in sustainable management of natural resources or NTFP	44	50	49	37	17	42
Play a role in manage natural calamities or disaster	30	47	35	31	10	16
Go for plantation activity	41	47	43	47	30	42
Help to forest department to control fire in forest	44	47	44	41	31	48
Weighted score	191	227	182	156	149	220

Table 2. Role of tibals in ecotourism in Anamalai Biosphere Reserve, Tamil Nadu, India

Ecotourism status	Kadar	Muduvar	Malasar	Malai malasar	Eravalar	Pulayar
Availability of employment related to ecotourism	20%	0	28%	26%	100%	32%
Respondent participation in ecotourism	20%	0	21.42%	0	8%	0
Satisfaction while doing the role	100%	0	100%	0	100%	0
Family member engaged in ecotourism	10%	0	10.17%	0	2%	56.25%
Member of village engaged in ecotourism	100%	0	100%	100%	100%	56.25%

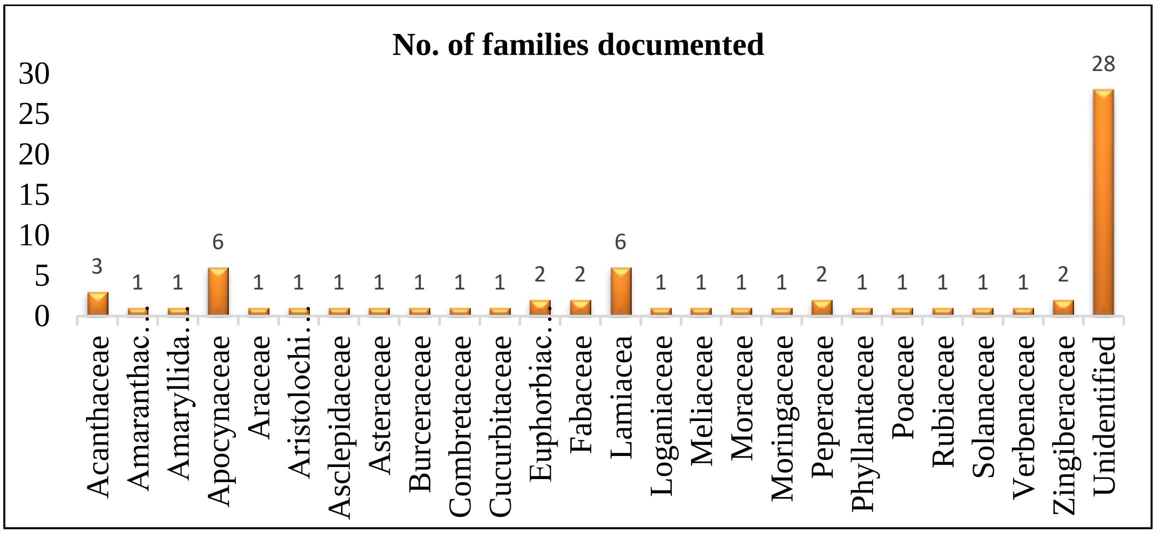

Fig. 1. Number of families documented during indigenous traditional knowledge surevey among tribes in Anamalai Biosphere Reserve, Tamil Nadu, India

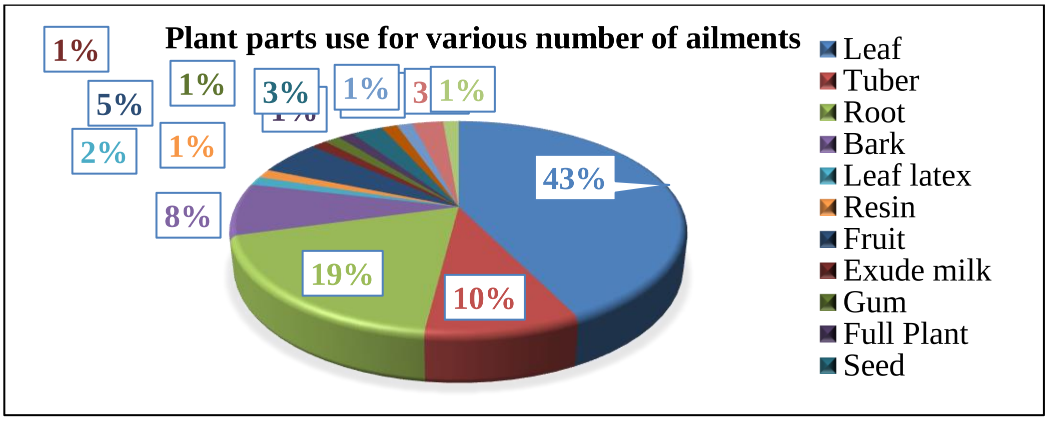

Fig. 2. Plant parts used by the tribals for different ailments in Anamalai Biosphere Reserve, T.N.

References

Chandi M 2008. *Tribes of the Anamalais: Livelihood and Resource-use Patterns of Communities in the Rainforests of the Indira Gandhi Wildlife Sanctuary and Valparai Plateau.*Nature Conservation Foundation, Mysore, India, p 90.

Revathi P and T Parimelazhagan 2010. Traditional Knowledge on Medicinal Plants Used by the Irula Tribe of Hasanur Hills, Erode District, Tamil Nadu, India. *Ethnobotanical Leaflets* **2010**(2):4.

5.5/T_5-38

Assessment of Sustainability through Criteria and Indicators Framework: A case of Forest in Akola Forest Division, Maharashtra, India

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Keyword: Sustainability, criteria and indicators, biodiversity, SFM

1. Introduction

The first Earth Summit at Rio in 1992, it was realized that Sustainable Forest Management (SFM) is an important element of Sustainable Development. The over-exploitation and the consequent depletion of forests due to several biotic and abiotic factors over time poses a serious threat to the livelihood of millions of poor people, biodiversity and ecology. In view of this, it is an imperative now to preserve the forests and manage them sustainably so as to ensure livelihood security of the forest-dependent communities and ecological integrity of the country, particularly of Akola District in Maharashtra. With view to harness the degradation and overexploitation of forest resources in the Akola Forest Division, its periodic monitoring is essential. The Criteria and Indicators (C&I) is one of the world-recognized tools for SFM. Hence the aim of the study is to identify set of indicators and factors responsible for increase and decrease value of indicators for sustainable forest management of forest in Akola Forest division.

2. Material and methods

The present study was conducted in Akola Forest Division to identify set of indicators for SFM for forest in Akola Forest division and study the factors responsible for decrease and increase value of indicators. The methodological frame work for evolving C & I will be adopted were developed for forests in Akola Division with community participation and different stakeholders together with approach for their data collection and analysis of sustainability.

Table 1. Criteria and Indicators for forests in Akola Forest division

Criteria No.	Title	National level indicators	Site specific indicators	Sustainability value
Criteria 1	Maintenance/increase in the extent of forest and tree cover	04	02	5.13 (+)
Criteria 2	Maintenance, Conservation and enhancement of biodiversity	05	02	5.32 (+)
Criteria 3	Maintenance and Enhancement of forest health and vitality	05	Nil	4.67 (-)
Criteria 4	Conservation and maintenance of soil and water resources	02	01	5.20 (+)
Criteria 5	Maintenance and enhancement of forest resource productivity	03	Nil	5.16 (+)
Criteria 6	Optimization of forest resource utilization	04	04	5.09 (+)
Criteria 7	Maintenance and enhancement of social, cultural and spiritual benefits	03	01	5.88 (+)
Criteria 8	Adequacy of Policy, Legal and Institutional framework	06	Nil	6.75 (+)
	Total	32	10	
	Sustainability index of forests in Akola Forest division			5.40 (+)

3. Results and discussion

Total 8 criteria's and 42 indicators had been identified for the forest in Akola Forest division, Maharashtra (Table 1). Out of which, the 32 national level indicators and 10 site specific indicators are applicable for forest in Akola Forest Division. Out of 8 criteria, all criteria (Criteria 1,2,4,5,6,7,8) shows sustainable condition expect criteria 3. In all the sustainable value of Akola Forest was recorded as 5.40 indicating the sustainable condition of Akola Forest. Hence the efforts should be made to improve the condition of the forest. In total 42 set of indicators have been identified out of which 32 are national indicators along with 10 site specific are applicable to forest in Akola Forest Division. The outcome of the project will be directly benefited to forest dwellers and the government functionary for the assessment of the sustainability of the forest.

5.6/T_5-47

Impact of Joint Forest Management Programme on Rural Livelihood in Malrajura village of Akola District Maharashtra India

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Keyword: Joint-forest management, NTFPs, livelihood, relational analysis

1. Introduction

JFM involves participation of people in managing forest. Forest department collaborate with the village people and share ownership and social, environmental and economic benefits by forming village committees. The present study based on Impact of JFM Programme on Rural Livelihood in Malrajura village of Akola District.

2. Material and methods

1) Locale of Study: Study was done of 30 respondents at Malrajura village, District- Akola, State- Maharashtra.
2) Preparation of Interviews and Questionnaires: It includes general information, personal, socio-economic characteristics of respondents, impact of change in annual income employment and availability of NTFP and Constraints faced by respondents. References such as Tariq (2021), Thigale et al (2018) used in the study.
3) Collection of Data: Two methods i.e., primary and secondary data collection will be used.
4) Variables and their Measurements: The independent variables such as age, education, land holding, Livestock etc. The dependent variables such as impact on change in annual income, employment and availability of non-timber forest produce.
5) Vegetation Analysis Through Quadrate sampling.
6)Livelihood Opportunities through JFM
6) Constraints: Faced by respondents

3. Results and discussion

Distribution analysis: Majority (43.34%) of the respondents belongs to the age group of above 51 year, followed by (33.33%) belonging to 36 to 50 years. Majority 23.33% of respondent were illiterate and having education up to middle school, followed by 20% respondent were educated up to college. Equal respondents (20%) were having marginal small and medium category of land holding. Majority of respondents (43.33%) having small category of livestock, while (23.34%) of respondent having animals of middle size category.

Relational analysis: Overall impact shows that annual income, employment and availability of NTFP shows positive and significant impact.

Table 1. Testing the significance of difference of the means in change in annual income, employment and availability of non-timber forest produce

Dependent Variable	Before Participation in JFM	After Participation in JFM	Impact	Percent Impact
Annual Income	45,423	54,293	8,870	19.52%
Employment	106.36	122.9	16.6	15.61%
Availability of NTFP	46.32	59.4	12.98	27.96%
				ΔI=63.09%

Livelihood Opportunities: Majority of respondents found Tendu leaves Collection as best livelihood opportunities in the village with 77.33%followed by aquaculture (44%), Mahua flowers collection (33.66%), Biba collection (23.66%), and apiculture (20.66%).
Constraints: Less price for NTFP in market is major constraint faced by the respondent *i.e.,* 24(80%), followed by 21(70%) processing units were not available in the village and government support in term of money 19(63.33%)

References

Tariq Iqbal 2021. Constraints analysis of JFM programme in Jammu division of J-K. *Indian journal of extension education* **57**(3):102-105

Thigale MB, Taide YB and Deshmukh HK 2018. Impact of JFM programme of livelihood of rural people of Akola district of Maharashtra. *PDKV Res J. Vol.* **42**(1)

5.7/T_5-50

Distribution and Phenology of *Syzygium stocksii* (Duthie) Gamble (Myrtaceae): An Endangered tree species in South Konkan

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Keyword: *Syzygium stocksii*, phenology, distribution, snowball sampling

1. Introduction

Syzygium stocksii (Duthie) Gamble is an Endangered evergreen tree species (WCMC 1998) endemic to southwestern states of India. Page (2017) reported it as rare along forest streams and swamps within 40-80 m elevation range and put it into Data Deficient category. Despite being first described from Konkan region, this species is a less-known rarity in Maharashtra (Hooker 1880, Cooke 1905).

2. Material and methods

The present study used snowball sampling method to assess the distribution of *S. stocksii* in South Konkan *i.e.* Ratnagiri and Sindhudurg districts. Phenological studies were carried out during 2021 on trees at three different locations by using General BBCH scale.

3. Results and discussion

Snowball sampling produced 5 different locations-all beside streams and total 78 trees in Sindhudurg and Ratnagiri districts. Contrary to the reported rarity, the present study reports sizeable populations. Further systematic explorations will lead to better understanding the exact status of *S. stocksii* in Konkan region. Present study has recorded the progression of reproductive phenophases for *S. stocksii* for the first time. Overall, the trees remained in the vegetative flush till meteorological week (MW) 9. Inflorescence Emergence started during MW 10 and peaked during MW 14. Flowering prevailed dominantly along with Fruit development during MW 18. Fruit maturity was maximum during MW 23. The large North-South distance between two locations did not affect the inflorescence emergence. A pictorial depiction of phenophases of *S. stocksii* is presented for the first time. This rare and endemic species is threatened by habitat modification and exploitation for timber.

References

Cooke T 1905. The Flora of the Presidency of Bombay. Vol. 1, Taylor & Francis, London.; Pp. 491.
Hooker JD 1880. Flora of British India Vol. 2, L. Reeve & Co, London. Pp. 498.
Page N 2017. Endemic Woody Plants of the Western Ghats: A Photographic Guide. Pp. 210.
WCMC [World Conservation Monitoring Centre] 1998. *Syzygium stocksii*. *The IUCN Red List of ThreatenedSpecies* 1998:e.T31201A9611615. https://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T31201A9611615.en. Accessed on 31 December 2022.

5.8/T_5-51

Chlorophyll Content of Teak (*Tectona grandis* Linn. F) under Different Irrigation Regimes Through Drip System in Early Growth Phase

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Keyword: *Tectona grandis,* chlorophyll, irrigation regimes, fertigation

1. Introduction

Teak (*Tectona grandis* Linn. F) is recognized as 'the paragon of timbers' (Masilamani and Annadurai 2003) owing to its highest timber value and it is the world's premier hardwood timber. Drip irrigation systems are most effective method of applying water and nutrients which generates a restricted root system requiring minimum nutrient supply. Hence, the study was performed for the optimization of water and nutrient requirement for teak through drip irrigation system.

2. Material and methods

A field experiment was carried out during 2020-2021 at Pachapalayam, Coimbatore, Tamil Nadu to study the chlorophyll content by acetone method under different irrigation regimes in eight months old teak plantation. The experiment design followed was split plot design which consists of four irrigation levels *viz.*, I_1 - 50%, I_2 - 75%, I_3 - 100%, I_4 - 125% of calculated water requirement of tree (WRt) as a main plots and four fertigation levels *viz.*, F_1 - 75%, F_2 - 100%, F_3 - 125%, F_4 - 150 % of recommended dose of fertilizer (RDF) as sub plots. The conventional method of irrigation (surface application) and fertilization (soil application) was kept as control. The RDF for teak has been taken as 150:100:100 kg ha^{-1} (Balagopalan et al 1998).

3. Results and discussion

From this study, it was found that the various irrigation and fertigation regimes of teak plantation had a significant difference on the chlorophyll content of leaves. In the study, the fertigation treatment F_3 with 125 % RDF level was observed to be the best fertigation treatment, with maximum chlorophyll 'a' value of 1.385 mg gm^{-1}, chlorophyll 'b' value of 0.490 mg gm^{-1} and total chlorophyll content value of 1.360 mg gm^{-1}. Among the different irrigation treatments, the best irrigation treatment for chlorophyll 'a' was I_2 (75 % of PE) with value of 0.980 mg gm^{-1}, the chlorophyll 'b' and total chlorophyll content was found maximum in I_3 (100 % PE) with value of 0.486 mg gm^{-1} and 1.480 mg gm^{-1}, respectively.

Table 1. Chlorophyll content of leaves (mg gm-1) at 8th month after fertigation

Treatments	Chlorophyll 'a' (mg gm^{-1})				
	I_1	I_2	I_3	I_4	Mean
F_1	0.093	0.532	0.632	0.512	0.578
F_2	0.501	1.001	0.721	0.615	0.690
F_3	1.182	1.535	1.541	1.291	1.385
F_4	0.872	1.215	1.392	1.005	1.171
Mean	0.710	0.980	0.960	0.740	
		I	F	I at F	F at I
SEd		0.028	0.018	0.042	0.037
CD (p=0.05)		0.070**	0.040**	0.096	0.080
Conventional method			SEd		CD
Cm vs IF	0.512		0.014		0.035

Table 1 continued

Treatments	Chlorophyll ‘b’ (mg gm^{-1})				
	I_1	I_2	I_3	I_4	Mean
F_1	0.109	0.301	0.336	0.400	0.310
F_2	0.327	0.445	0.465	0.435	0.445
F_3	0.387	0.485	0.511	0.557	0.490
F_4	0.370	0.425	0.572	0.528	0.476
Mean	0.298	0.414	0.486	0.470	
		I	F	I at F	F at I
SEd		0.008	0.006	0.013	0.013
CD (p=0.05)		0.020**	0.014**	0.031	0.028
Conventional method				SEd	CD
Cm vs IF	0.270			0.0081	0.0203
Treatments	Total chlorophyll (mg gm^{-1})				
	I_1	I_2	I_3	I_4	Mean
F_1	0.482	0.610	0.512	0.330	0.480
F_2	0.660	0.990	0.850	0.763	0.820
F_3	1.158	1.523	1.890	1.415	1.360
F_4	1.108	1.310	1.525	1.319	1.250
Mean	0.680	1.320	1.480	0.740	
		I	F	I at F	F at I
SEd		0.012	0.017	0.030	0.034
CD (p=0.05)		0.031**	0.036**	0.067	0.072
Conventional method				SEd	CD
Cm vs IF	0.455			0.033	0.084

References

Balagopalan M, Rugmini P and Chand Basha S 1998. "Soil nutrient management for teak plantations of Kerala.”

Masilamani P and Annadurai K 2003. Seedling vigour of irrigated teak (*Tectona grandis* Linn F). *Indian Journal of Forestry* **26**(1): 48-52.

5.9/T_5-60

The Effect of Elevated CO_2 on Growth and Yield Parameters of Groundnut Genotypes (*Arachis hypozeae* L.)

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Keywords: CO_2, genotypes, growth, agriculture crop

1. Introduction

The future climate change is projected to have increased concentration of CO_2 in the atmosphere. The concentration of tropospheric CO_2 has progressively increased from about 280 to 411 µmol/mol from the pre-industrial revolution to present and which is likely to reach 450-600 µmol/mol between 2030 and 2052, As it is well known that CO_2 is an important plant nutrient which could enhance crop growth and productivity (Erda *et al*. 2005) Results from Open top chambers (OTC), experiments indicated that eCO_2 resulted in higher biomass production in groundnut.

2. Material and methods

For the present experiment, three open top chambers were selected having the diameter of 7.4 m^2 with transparent PVC (polyvinyl chloride) sheet having 90% transmittance of light. to find out the effect of eCO_2 on growth and yield parameters of groundnut *Arachis hypozeae* L. Five groundnut genotypes - TG 86, TG 84, TG 82, Mallika and Gangapuri were evaluated under open atmosphere condition, ambient CO_2 and elevated CO_2 concentration of (450 & 500 ppm) at the research farm, College of Agriculture, Gwalior during *kharif* 2019. The crop was grown inside the chambers as well as under the natural conditions.

3. Result and discussion

The growth and yield parameters of selected five groundnut genotypes showed positively to elevated CO_2 concentration (500 ppm) at different growth stages. among all the genotype TG 86 recorded highest growth and yield parameters with increasing level of eCO_2 (500 ppm) in terms of plant height, no. of nodules, no. of pods/plant, pod yield, kernel yield & yield attributes, which may be reasoned to the fact that the carbon dioxide has direct fertilizing effect on plant growth & Groundnut. Being a C_3 leguminous plant has shown positively to eCO_2 (500 ppm) & showed increase in photosynthetic rate, total biomass compared to the aCO_2 condition (Stanciel et al 2002). Increased yields with different CO_2 levels are also be explained by positive correlation between yield attributes with yield of groundnut.

Table 1. Influence of CO_2 and genotypes of groundnut on yield attributes

	Yield attributes						
Factor A (CO_2 levels)	No. of pods / plant	Pod weight / plant (gm)	100-kernel weight (gm)	Shelling (%)	Sound Mature kernel (%)	Haulm yield/ plant (gm)	Pod yield/ plant (gm)
Open atmosphere	30.0	16.3	22.4	62.2	80.5	34.6	10.3
Ambient CO_2	31.6	16.9	23.4	64.6	82.8	37.0	12.1
CO_2 Concentration 450 ppm	34.4	17.6	24.6	65.2	84.0	42.5	14.5
CO_2 Concentration 500 ppm	34.8	19.7	26.0	66.4	86.2	54.3	18.1
SEm±	0.48	0.35	0.27	0.88	0.45	1.71	0.58
CD(0.05)	1.49	1.08	0.82	2.72	1.38	5.27	1.80

Factor B (genotypes)							
TG 86	35.0	18.8	27.3	68.2	87.8	50.8	16.7
TG 84	34.0	17.8	25.5	66.5	86.1	46.7	15.1
TG 82	32.5	17.4	24.5	63.8	84.1	42.5	13.6
Mallika	32.5	17.9	22.8	63.8	84.4	40.4	13.3
Gangapuri	29.5	16.2	20.5	60.9	74.5	30.2	10.2
SEm±	0.54	0.39	0.30	0.99	0.50	1.91	0.65
CD(0.05)	1.66	1.21	0.92	3.04	1.54	5.89	2.01

References

Erda L, Wei X, Hui J, Yinlong X, Yue L, Liping B, Liyong X 2005. Climate change impacts on crop yield and quality with CO_2 fertilization in China. Philos Trans R Soc Lond B *Biol Sci*. 29;360(1463):2149-54.

Stanciel K, Mortley DG, Hileman DR, Loretan PA and Bonsi CK 2002. Growth, pod, and seed yield, and gas exchange of hydroponically grown peanut in response to CO_2 enrichment. *Hort. Science*., 35: 49-52.

5.10/T_5-68

Studies on Natural Regeneration of Dollar Earning Parasite (*Santalum album* Linn.) in Himachal Pradesh, India

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Keyword: *Santalum album*, regeneration, recruit, regeneration, stocking

1. Introduction

The distribution of *Santalum album* is mostly in the deciduous forests of the Deccan region of Peninsular India and is found mainly growing naturally in the states of Karnataka and Tamil Nadu. In Himachal Pradesh, the sandalwood is found growing naturally in districts of Kangra and Bilaspur.

2. Material and methods

The regeneration survey of two sites Jawalji (Kangra) and Dholra (Bilaspur) was carried out in all the major sample plots. Within each sample plot (31.62×31.62 m) three sub-quadrat per plot of size (2×2m) for regeneration studies were laid down. To express satisfactory regeneration 2500 established plant per hectare were desired. The quadrate was considered fully stocked when it contained on established plant. The regeneration survey was conducted from recruits (r) which may be defined as current years seedlings, unestablished regeneration (u) seedlings other than recruits which has not established and whose height was less than 2 m, here four established plants were taken equivalent to one established plant and established regeneration (e) having height more than 2 m.

3. Results and discussion

The data pertaining to regeneration status of two different sites are presented in Table 1. In Jawalaji (Kangra) site, *S. album* showed the maximum number of recruits (150.00 ha^{-1}), unestablished (250 ha^{-1}), established (50 ha^{-1}), establishment stocking per cent (3.32%) and successful regeneration (4.50%). *Leucaena leucocephala* showed number of unestablished (100 ha^{-1}) and successful regeneration (1.00%) whereas recruit's, established and establishment stocking per cent were found absent in *Leucaena leucocephala.*

Table 1. Regeneration status at Jawalaji (Kangra) and Dholra (Bilaspur) site in Himachal Pradesh

Name of species	Recruits (ha^{-1})	Unestablished (ha^{-1})	Established (ha^{-1})	Establishment stocking percent (%)	Regeneration successful (%)
Jawalaji (Kangra)					
Santalum album	150.00	250.00	50.00	3.32	4.50
Leucaena leucocephala	-	100.00	-	-	1.00
Total	150.00	350.00	50.00	3.32	5.50
Dholra (Bilaspur)					
Santalum album	450.00	450.00	100.00	4.59	8.50
Leucaena leucocephala	-	250.00	100.00	4.93	6.50
Mallotus phillipensis	200.00	-	50.00	2.00	2.00
Albizzia lebbeck	250.00	200.00	50.00	2.28	4.00
Total	900.00	900.00	300.00	13.81	21.00

In Dholra (Bilaspur), *S. album* showed maximum number of recruits (450.00 ha^{-1}), unestablished (450.00 ha^{-1}), established (100.00 ha^{-1}), establishment stocking per cent (4.59%) and regeneration successful (8.50%) as compared to other species followed by *L. leucocephala*, which showed unestablished (250.00 ha^{-1}), established (100.00 ha^{-1}), establishment stocking per cent (4.93%) and regeneration successful (6.50%). *Albizzia lebbeck* showed recruits (250.00 ha^{-1}), unestablished (200.00 ha^{-1}), established (50.00 ha^{-1}), establishment stocking per cent (2.28%) and regeneration successful (4.00%). *Mallotus phillipensis* showed recruits (200.00 ha^{-1}), established (50.00 ha^{-1}), establishment stocking per cent (2.00%) and regeneration successful (2.00%) whereas recruit's (ha^{-1}) in *L. leucocephala* and unestablished in *M. phillipensis* were found absent.

5.11/T_5-71

Assessment of Wetland Ecosystem Services (RAWES approach) in Urban Settlement Areas: A case study of Bilaspur, Chhattisgarh, India

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Keywords*:* Wetland, ecosystem services, rapid assessment, urban settlement, degradation

1. Introduction

The wetland ecosystem provides several services that support and improve wellbeing of humans. In rapid urbanization, the growing urban population can get benefit from wetland ecosystem services that are of prior importance. To comprehend the significance of the wetlands in an urban area, a study was conducted to evaluate the ecosystem services offered by 20 wetlands of Bilaspur, Chhattisgarh.

2. Material and methods

This paper presents a case study from urban wetlands by the implementation of RAWES approach. Based on RAWES, a consensus was done to finalize the list of ecosystem services prior to conducting field assessments. A five-point scale was developed to evaluate the relative importance of each listed ecosystem service. Obtained scores was then numerically transformed and further analysed by deriving Ecosystem Services Index. Scale of services and vegetations were also analysed to evaluate the ecosystem services provided by urban wetlands.

3. Results and discussion

The results evinced that out of 20 wetlands, GGV Pond 2 and GGV Pond 1 achieved highest ecosystem service scores (26 and 25 respectively) whereas least ecosystem service score was observed in Karbala Pond (-11). The highest Ecosystem Service Index among different categories was observed in Regulating services (0.66) and the lowest in Provisioning services (0.32). Based on the findings, the most beneficial contribution was water regulation and primary production (+ = 15 each). In contrast, livestock disease regulation (- = 16) was the most detrimental ecosystem service. The vegetation around the wetlands was dominated by *Ficus religiosa and Acacia nilotica.* The RAWES technique was found significant in evaluating the deteriorating state of Bilaspur's urban wetlands by assessing ecosystem services provided by them.

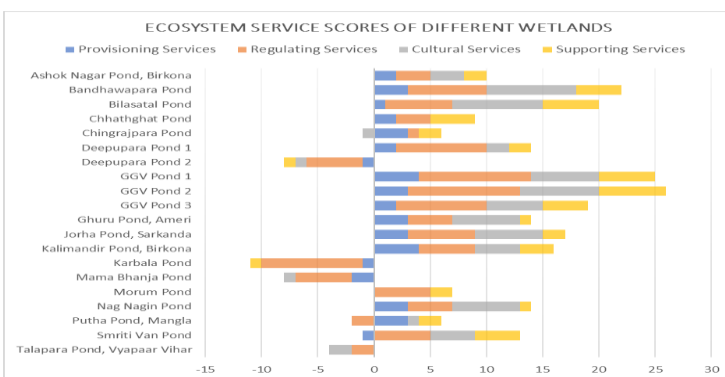

Figure 1. Graphical representation of wetland wise ecosystem service scores showing individual wetland scores achieved by 20 studied urban wetlands of Bilaspur, Chhattisgarh

References

Mc Innes RJ and Everard M 2017. Rapid assessment of wetland ecosystem services (RAWES): An example from Colombo, Sri Lanka. *Ecosystem Services* **25:** 89-105.

5.12/T_5-73

Distribution and Mapping of *Ficus neriifolia* Smith: A Multipurpose Agroforestry Tree in Chamoli District, Uttarakhand, India

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Keywords: *Ficus neriifolia*, altitudes, density, leaf fodder

1. Introduction

Genus *Ficus* commonly known as 'Figs', are considered as keystone species in tropical rainforests. This genus is an exceptionally large pan tropical genus with over 700 species (Berg, 1989) and belongs to the family Moraceae. The genus is distributed throughout the world primarily in subtropical and tropical regions (Berg and Corner, 2005) *F. neriifolia* (Dudhla/Thilook/Dudhoi) is the common tree species which are being cultivated in and around farmlands and they provide a source of leaves fodder during the dry season and very high animal feed in Nepal (Panday, 1982). The villagers use *F. neriifolia* leaves as good fodder because the thickness of cow's milk is also of good quantity.

2. Material and methods

The present study was conducted in Chamoli district in the North-Eastern part of Uttarakhand. In the first stage, out of nine developmental blocks, the species occurs in eight blocks. In the second stage of sampling, a detailed questionnaire-based survey in each selected village was conducted. The total thirty-three villages/sites were selected randomly from eight developmental blocks in the district. Habitat mapping of *F. neriifolia* across the Chamoli region was conducted. During the field survey, the GPS point were taken the reference point of habitat location of *F. neriifolia* in different areas in the district was noted.

3. Result and discussion

We surveyed all the 9 blocks in Chamoli District and the species occurrence was in 8 blocks. Out 8 blocks, the species were found in a total 33 villages. Among the 33 surveyed villages GPS location were noted and a map was prepared with the help of the GPS point. As far as tree population of *F. neriifolia* is concerned, maximum density (45 tree/200 m^2) was recorded, in Dewal block. The higher density in Dewal site may be due to higher altitude and low temperature for suitable habitat conditions for its growth and development.

References

Berg CC 1989. Classification and distribution of *Ficus*. *Experimentia* **45**: 605-611.
Berg CC and Corner EJH 2005. Moraceae – Ficus. *Flora Malesiana*, series 1 (Seed Plants), **17**: 1-730.
Pandey KK 1982. Fodder trees and tree fodders in Nepal. Swiss Federal Institute of Forestry Research, SDC (A report), 107pp.

5.13/T_5-74

Biomass and Carbon Sequestration of *Populus deltoides-Curcuma longa* based agri-silviculture system in India Western Himalayas: A Case Study

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Keywords: Climate smart, carbon sequestration, *Populus deltoides*, agri-silviculture, biomass

1. Introduction

Climate change is one of the most defining concerns of today's world and has greatly reshaped or in process of altering earth's ecosystems. In order to tackle this, a climate smart multifunctional system is needed and agroforestry is such a sustainable land use system that provides win-win opportunity by creating synergies between adaptation and mitigation strategies.

2. Material and methods

An on-farm experiment was conducted to evaluate biomass and carbon sequestration potential of *Populus deltoides-Curcuma longa* agri-silviculture system, where *C. longa* var. Palam Pitambar was grown under two *P. deltoides* (G-48 clone) tree spacings (S_1: 6 × 4 m and S_2: 4 × 4 m) and in open field (S_0) during *Kharif* 2019-2021 at Solan (India). Tree biomass was estimated non-destructively using species-specific allometric equations (Das et al 2011) whereas crop biomass was estimated destructively and further multiplied with IPCC default value 0.5, to acquire carbon density. Soil carbon density was quantified by multiplying values of bulk density (g cm^{-3}), SOC (%) and soil depth (cm) (Nelson and Sommers 1996). Furthermore, rate of carbon sequestration was determined by multiplying 3.6663 with carbon density.

Table 1. Biomass, carbon density and carbon sequestered (Mg ha^{-1}) under poplar based agroforestry system *vis à-vis* open field condition cropping

Tree spacings	Crop biomass	Tree biomass	Crop carbon	Tree carbon	Carbon sequestered in tree	Soil carbon	Total ecosystem carbon	Overall carbon sequestered
S_1:6 m × 4 m	0.29^a	137.33^a	0.14^b	66.38^a	242.94^a	52.52^a	119.04^a	436.47^a
S_2:4 m × 4 m	0.28^b	94.36^b	0.14^b	45.60^b	166.90^b	55.68^a	101.42^b	371.88^b
S_0:open field	0.34^c	-	0.17^a	-	-	40.75^b	40.92^c	150.04^c
$CD_{0.05}$	0.01	1.43	0.01	3.47	13.68	6.42	5.23	19.68

Values followed by same letter are not statistically significant.

3. Results and discussion

The results evinced that *P. deltoides* tree spacings exhibited significant effect on biomass, carbon density and carbon sequestration rate, where significantly higher value of crop biomass (0.34 Mg ha^{-1}) and crop carbon density (0.17 Mg ha^{-1}) obtained in open field (S_0) than under agrisilviculture system ($S_1 > S_2$). Tree biomass (137.33 Mg ha^{-1}), tree carbon density (66.38 Mg ha^{-1}) and total ecosystem carbon density (119.04 Mg ha^{-1}) were found maximum under S_1 and followed the order: $S_1 > S_2 > S_0$ while, higher soil carbon density (55.68 Mg ha^{-1}) was recorded under tree spacing S_2. Correspondingly, the total carbon sequestered as well as carbon sequestered in trees was higher (436.47 and 242.94 Mg ha^{-1}, respectively) under S_1. Monetary value of the total carbon sequestered was estimated to be US$2226 ($S_1$)>US$1897 (S_2)>US$765 ($S_0$) @US$ 5.1 Mg CO_2-e. Overall, the study concluded that in *P. deltoides-C. longa* agrisilviculture system poplar trees planted at wider spacing (S_1) sequestered more carbon with higher net increment than S_2 and $S_{0,}$ henceforth recommended for getting better economic returns, preserving soil fertility and mitigating climate extremities

Reference

Das DK, Chaturvedi OP, Jabeen N and Dhyani SK 2011. Predictive models for dry weight estimation of above and below ground components of *Populus deltoides* in India: Developmemt and comparative daiagnosis. *Biomasss Bioenergy* **35**:1145-1152.

Nelson DW and Sommers LE 1996. Total carbon, organic carbon and organic matter, in: Page, A.L. (Ed.) *Methods of soil analysis*: *Part 3 Chemical methods*, Book Series no. 5. Soil Science Society of America Inc., Madison, pp 961-1010.

5.14/T_5-76

Ethnomusicology, Taboos and Totems of Kukna Tribe: A Case Study from Kaprada Range in Dharampur Forests, Gujarat, India

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Keywords: Ethnomusicology, taboos, Kukna Tribe, instruments

1. Introduction

Kaprada forests forms one of the rich floral diversity pockets in South Gujarat region inhibited mainly by Kukna tribe. Area was explored taxonomically in 1987, leaving behind lacunae in ethnobotanical documentation. Present study was conducted in 2021- 2022 to gather information on how plants are associated with lifestyle of Kukna tribe. Kukna tribe is known for cultural heritage and hence information on ethnomusicological aspects along with totems and taboos were collected.

2. Material and methods

Proforma on sacred groves were made and also translated in local language for interviewing tribal people (bhagats and bhuvas) and also elderly person. Data on sacred groves like which taboo/totem is involved, plant species worshipped and conserved were reported. Tribal festivals, tribal markets and religious ceremonies/rituals were also attended and visited to collect information on tribal uses of plant.

Table 1. List of Musical Instruments used by tribes of Kaprada Forests – Ethnomusicology

Sr. No.	Instruments with their representative forms	Tribe utilizing instruments
1.	Tarpa – form of Trumphet / Buggal	Kukna, Varli
2.	Ghadse – form of Drum and Trumphet	Kukna
3.	Kahli – form of Drum and Trumphet	Kukna
4.	Tur – form of Vrundang/Brudang	Kukna, Varli, Dhodiya
5.	Nagara – form of Drum	Kukna, Varli
6.	Dhak – form of Damru	Kukna
7.	Ghangli – form of Mandolin	Kukna, Varli
8.	Dhol – form of Drum	Kukna, Varli
9.	Pavi – form of Flute	Kukna

3. Results and discussion

Total of five sacred groves, 12 sacred plants and 09 musical instruments are reported. Besides this, 10 tribal festivals were also attended to document different plants. The major festivals celebrated by the tribal inhabitants of the area are “Holi, Baras and Dev”. A major musical instrument of Kukna tribes is “Tarpa, Kahli, Ghadse, Ghangli” these instruments use by Kukna tribes on different festivals & religious ceremonies like marriage, mavli, deva *etc*. The rural inhabitant and tribal peoples do not have any well-defined conservation strategy of the kind we understand in modern terms. But they do conserve plants that are socially, medically, economically and culturally significant to them.

5.15/T_5-77

Selection and Evaluation of Candidate Plus Trees of *Toona Ciliata* under Jammu Sub Tropics, (J&K) India

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Keywords: Candidate plus trees (CPTs), *Toona ciliata,* seedling, growth, biomass, Seedling quality

1. Introduction

Toona ciliata, belonging to family Meliaceae, is a naturalized species in India and one among various agroforestry species which is largely preferred by the farmers to be grown on their farms for its high timber value. In Jammu and Kashmir, it occurs in subtropical and intermediate climate of Jammu, Samba, Reasi, Rajouri, Udhampur and Kathua districts in scattered manner. Therefore, in order to boost the cultivation and productivity of this multipurpose tree species, it is necessary to select different candidate plus trees to screen out the superior candidate plus trees among the existing population, so that quality planting material may be provided to the farmers/growers. For this purpose, nursery evaluation of different candidate plus trees of *T. ciliata* after selection was undertaken.

2. Material and methods

The present investigation was carried out at Experimental Farm of Division of Agroforestry, Sher-e-Kashmir University of Agricultural Sciences and Technology, Chatha, Jammu, India. The extensive survey was undertaken in six districts of subtropical and subtemperate regions of Jammu during September 2020-April 2021, representing the entire range of distribution of *T. ciliata* in the J&K Union Territory to mark the candidate Plus trees. The selection criteria for the current study was based on base line methodology. Capsules were manually collected from the marked CPTs during the 1st fortnight of June and sown in polybags on 24th June. The experiment was laid out in CRD with 22 treatments (CPTs) and three replications. The data was subjected to statistical analysis of randomized block design using OPSTAT software.

3. Results and discussion

Tree height, clear bole height, DBH, crown diameter, number of branches and straightness score were recorded for selected CPTs and ranged between 11.63- 26.13 m, 2.18-8.19 m, 27.36-43.56 cm, 7.34-12.45 m, 10-27 and 3-5, respectively. CPT-4, CPT-5, CPT-6, CPT-14, CPT-16, CPT-17, CPT-18, CPT-19, CPT-20 and CPT-22 exhibited higher values for tree characteristics. Similar selection procedure was adopted by Singh (2021) Seeds were collected from each plus tree and progenies were raised and evaluated for growth, biomass and seedling quality traits under nursery conditions. Considerable variation was also observed among progenies for germination percentage (25.54-96.67%), survival percentage (59.08-87.23%), seedling height (35.22-49.69 cm), collar diameter (6.05-9.94 mm), number of leaves (51.29-77.08), number of branches (6.47-10.53), primary root length (17.50-31.98 cm), fresh shoot weight (11.74-21.59 g), dry shoot weight (4.28-7.66 g), fresh root weight (6.21-11.65 g), dry root weight (2.06-4.54 g), total fresh biomass (18.88-33.24 g), total dry biomass (6.83-11.61 g), seedling quality index (1.02-1.96), sturdiness quotient (4.74-6.57) and root: shoot ratio (0.38-0.74). CPT-1, CPT-2, CPT-3, CPT-11, CPT-14, CPT-15, CPT-16 and CPT-18 were found to be outstanding for seedling growth and vigour. Therefore, these CPTs can be used for the production of quality planting material and further improvement in the species.

Reference

Singh R 2021. *Assessment of genotypic variation for morpho-physiological characteristics of Toona ciliata M. Roem.* M.Sc. Thesis, Punjab Agricultural University, Ludhiana, Punjab, India.

5.16/T_5-78

Land Rehabilitation through Agroforestry-A case study of Central Kashmir, Himalayas, India

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Keywords: Agroforestry, Himalaya, rehabilitation, soil improvement, degraded lands

1. Introduction

Jammu and Kashmir a mountainous state of country has large area under waste lands and it is need of the hour to rehabilitate them for sustainable development. Among different optionsAgroforestry is one of the best practices for rehabilitation of thesedegraded landscapes because it involves planting of trees component, agricultural crop component, grasses, fruit component, medicinal plant, livestock in different combinations.In this context, Faculty of Forestry, SKUAST-K, Benhama campus situated on southern slopes having rugged terrain was considered for rehabilitation through development of agroforestry models. These agroforestry models include various region specific models like agri-silviculture, silvi-pastoral, agri-horticulture, agri-silvipastoral and silvimedicinal. These models have been successful in terms of growth, development and socio-economic upliftment. Forest tree species like Elm, Populus, salix, acer, fruit tree species like wild Apricot apple, pear, peach, Cherry, almond have been planted in the lands under different systems and inter cropping with differentkindsof agriculture crops *viz*., beans, garlic, moong andmedicinal plantslike lavender, perennial grasses like orchard grass, tall fescu, red clover etc. Among different models one wild Apricot (which is also called hardy) based agroforestry system was started in the year 2014. The tree wild apricot has multifarious uses so it was selected as one of the species for rehabilitation of these lands. these

2. Material and methods

Wild apricot which is also called hardy was planted in the degraded lands of faculty of Forestry at a spacing of 3x3 m during the year 2014. Different agricultural crops *vi,z* onion, garlic (Rabi season) strawberry & French beans (Kharif Season) were grown as intercrops between the alleys. Different growth parameters were recorded yearly in terms of tree height, collar diameter, crop yield t/hectare, fruit yield, oil content (%) & fuel wood content. The experiment was concluded after a period of eight years.

Table 1. Growth and yield of some intercrops under apricot based agri-horticulture system

Treatment	Height (m)	Collar Diameter (mm)	Crop yield (t/ha)	Fruit Yield kg tree^{-1}	Oil Yield %	Fuel Wood kg Tree^{-1}
T_1 = Apricot + Onion	4.68	91.89	9.01	9.05	38.55	18.96
T_2 = Apricot + Garlic	5.30	100.57	4.01	5.98	37.05	17.90
T_3 = Apricot + Strawberry	5.04	91.86	2.0	5.99	37.07	17.96
T_4 = Apricot + French bean	5.98	101.99	1.01	6.10	37.98	17.82
T_5 = Apricot + Control (Natural grasses)	4.62	87.81	----	4.88	37.69	17.72
CD $p \leq 0.05$	0.17	1.89	1.16	0.15	1.21	0.72

3. Results and discussion

After completion of eight years maximum plant height (5.98m) and diameter (101.99mm) was recorded in treatment T_4 (Apricot+ French beans). Onion performed better as compared to other crops in combination with apricot by attaining a yield of 9.89 t/ha (Table 1). The average fruit yield per tree was recorded maximum with T_1 (6.10 kg Tree^{-1}) followed by (3.99 kg tree^{-1}) when beans were intercropped with Apricot. Also, oil content extracted from the kernels of harvested fruits ranged between 37.99 to 38.51%. Fuelwood ranged between 17.90 to 18.96 kg/tree in different treatments. It was concluded that apricot is the suitable tree species for the degraded lands of Kashmir valley and requires low inputs. The tree species was found to be resistant for different kinds of diseases and pests till date so requires low inputs. In the initial years both rabi and kharif vegetable can be grown as intercrops up to a period of 5years. After five years Rabi vegetables can be grown an intercrop as the tree being of deciduous nature. Fruit yield started increasing and good harvest of fruits can be obtained. More ever pruning and training needs to be done to increase fruit yield. Wild Apricot is recommended for rehabilitation of degraded Forest to overcome man verse animal conflict. The oil content having medicinal value and fetches good price in the market will result in enhancing overall income of farmers. The species is hardy in nature and can be used for rehabilitation of degraded land. Fuel wood of the tree species can be used by the farmers during harsh winters for cooking and heating purpose and timber for handles of Agriculture implements. This model has resulted in the improvement of microclimate of the southern slopes and the slope has turned into a lush green area.

5.17/T_5-86

Seasonal Variations in Physico-Chemical Parameters of Vellode Bird Sanctuary, Erode, Tamil Nadu, India

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Keywords: Vellode, water quality, physicochemical properties, seasonal variations.

1. Introduction

Wetlands constitute a wealth of our biodiversity (Bhat et al 2009). The health of the wetland is directly related to the water qualities. Therefore, the water quality analysis is very important to determine the health of the wetland and determining the physicochemical and biological factors is important, as they might affect directly or indirectly the distribution and production of fish, aquatic birds and animals (Sikoki and Veen 2004; Shib 2014). The purpose of the study was measuring the physicochemical parameters of Vellode bird sanctuary and to determine the seasonal changes of physicochemical parameters and to quantify the correlation relationship between different physicochemical parameters.

2. Material and methods

The pH was estimated by Digital pH meter (Systronics type-361), Electrical conductivity was analyzed by Digital conductivity meter 304 Systronics, total dissolved solids was recorded by digital conductivity meter and physicochemical parameters was done as per the guidelines of American Public Health Association, (2013). The nitrate, phosphate, sulphate, calcium, magnesium and sodium in the lake water were estimated by Atomic Absorption Spectrophotometer- Perkin Elmer method (Simpi et al 2011).

Table 1. Water quality parameters of Vellode Bird Sanctuary (July-2019 to May-2020)

Sr. No.	Parameters	Season		
		Monsoon	**Winter**	**Summer**
1.	pH	6.681 ± 0.41	6.491 ± 0.23	7.143 ± 0.18
2.	Electrical Conductivity (dS/m)	0.211 ± 0.01	0.319 ± 0.02	0.372 ± 0.02
3.	Total Dissolved Solids (mg/l)	141.6 ± 2.41	165.7 ± 7.40	189.6 ± 7.97
4.	Dissolved Oxygen (mg/l)	3.553 ± 0.37	3.080 ± 0.11	2.920 ± 0.16
5.	Biological Oxygen Demand (mg/l)	0.242 ± 0.03	0.380 ± 0.05	0.385 ± 0.05
6.	Chemical Oxygen Demand (mg/l)	164.6 ± 4.56	160.0 ± 3.74	30.27 ± 1.26
7.	Total Hardness (mg/l)	160.6 ± 15.97	156.0 ± 13.79	179.7 ± 7.87
8.	Nitrates (mg/l)	14.00 ± 3.51	9.951 ± 2.99	5.630 ± 1.55
9.	Phosphates (mg/l)	0.262 ± 0.04	0.107 ± 0.01	0.097 ± 0.01
10.	Chlorides (mg/l)	195.7 ± 18.0	205.1 ± 9.89	224.9 ± 6.33
11.	Sulphate (mg/l)	12.02 ± 5.50	14.00 ± 3.55	20.91 ± 1.59
12.	Calcium (mg/l)	88.22 ± 7.20	80.15 ± 7.94	75.64 ± 4.74
13.	Magnesium (mg/l)	52.08 ± 9.18	24.30 ± 6.06	31.11 ± 7.58
14.	Sodium (mg/l)	34.30 ± 4.78	30.92 ± 3.41	29.76 ± 1.10

***mean of 55 samples**

3. Results and discussion

The values of pH, electrical conductivity, total dissolved solids, total hardness, biological oxygen demand, chloride and sulphate were maximum in summer season [(7.14 ± 0.18), (0.372 ± 0.02 dS/m), (189.6 ± 7.97 mg/l), (179.7 ± 7.87 mg/l), (0.385 ± 0.05 mg/l), [(224.0 ± 6.33 mg/l) and (20.9 ± 1.59 mg/l)] respectively. The values of dissolved oxygen, chemical oxygen demand, nitrate, phosphate, calcium, sodium and magnesium were observed higher in monsoon season [(3.553 ± 0.37 mg/l), (164.6 ± 4.56 mg/l), (14.00 ± 3.51 mg/l), (0.262 ± 0.04 mg/l), (88.22 ± 7.20 mg/l), (34.30 ± 4.78 mg/l) and (52.08 ± 9.18 mg/l)] in the following order respectively.

Reference

American Public Health Association 2013. "APHA. 2005". *Standard Methods for the Examination of Water and Wastewater. 21st ed. American Public Health Association, Washington DC, 1220p*.

Bhat IP, Cristopher SS and Hosetti BB 2009. Avifaunal diversity of Anekere wetland, Karkala, Udupi district, Karnataka, India. *Journal of Environmental Biology* **30**(6):1059-1062.

Shib A 2014. Seasonal variations in physico-chemical characteristics of rudrasagar wetland-a Ramsar site, Tripura, North East, India. *Research Journal of chemical sciences* **4**(1), 31-40.

Sikoki FD and Veen JV 2004. Aspects of water quality and the potential for fish production of shiroro reservoir Nigeria. *Liv. Sys. Sus. Dev*. 2: 7pp.

Simpi B, Hiremath SM, Murthy KNS, Chandrashekarappa KN, Patel AN and Puttiah ET 2011. Analysis of water quality using physico-chemical parameters Hosahalli Tank in Shimoga District, Karnataka, India. *Global Journal of Science Frontier Research* **11**(3): 31-34.

5.18/T_5-89

Present Status of Mangrove Forest in India

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Keywords: Mangrove, coastal ecosystem, degradation, eco-tourism, conservation

1. Introduction

Mangroves can be defined as tree or shrub that grows above ground in slightly briny water that has low level of oxygen in soil. Mangroves are versatile species of coastal ecosystem which are serving the nature through there accessible and countless services. The aim of the study is to document the status of mangrove forest in India.

2. Material and methods

This paper is the review work based on published and technical reports related to mangrove ecosystem, their Importance for general wellbeing of communities, afforestation and conservation practices, distribution of mangroves in coastal region of Maharashtra, Tourism opportunities, threats for their survival and scope of research in field of mangroves.

3. Results and discussion

The mangroves are sources of unending commodities and several benefits to mankind. It provides different ecological economical and health benefits along with highly valued commercial products, fishery resources and sites for developing a burgeoning eco-tourism. There are between 60 and 100 species of mangroves worldwide, which are divided into more than 30 genera and 20 different families. India has been reported for holding the fourth largest mangrove cover in the world. Despite all those facts mangroves are under pressure for their survival and the need is to conserve them. Mangroves can be conserved by effective Governance structures, rehabilitation of degraded mangroves, education, awareness building in local communities for successful and effective management of mangroves such measures need to be used more comprehensively.

5.19/T_5-100

Soil Chemical Properties under Poplar - Wheat Agroforestry System in Tarai Lands of Pantnagar, Uttarakhand

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Keywords: Soil properties, agroforestry, poplar, wheat, organic carbon

1. Introduction

Soil degradation is a major threat to agricultural productivity. A solution to address such degradation is the adoption of agroforestry systems. An investigation was carried out to know the chemical characteristics of soil under poplar-based agroforestry system (Soil pH, electrical conductivity (EC), organic carbon (OC) and macronutrients (N, P and K) in 0-15 cm and 15-30 cm depth).

2. Material and methods

Wheat was grown under four year's old poplars of different planting stock. After harvesting of wheat crop, the soil sampling was done from all the plots of each treatment and each replication. The soil samples were collected from two profile depths (0-15 cm and 15-30). Thereafter, a composite sample was formed from this soil sample and was processed as per standard procedure. Property of soil is then analyzed using randomized bock design.

Table 1. Effect of open farming and poplar-based agroforestry systems on soil parameters

Treatments	pH		EC		SOC		N		P		K	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
T_1	7.84	7.54	0.42	0.32	1.07	0.98	252.9	213.0	21.99	18.13	219.3	190.9
T_2	7.83	7.60	0.42	0.32	1.04	0.99	252.2	213.4	18.16	21.69	218.8	190.6
T_3	7.72	7.58	0.42	0.24	1.05	1.07	251.4	211.2	21.08	18.11	218.9	191.1
T_4	7.82	7.61	0.41	0.32	1.05	1.03	252.4	213.3	18.28	21.58	219.3	191.5
T_5	7.78	7.59	0.41	0.31	1.05	0.96	251.4	211.3	21.61	18.12	219.6	191.1
T_6	7.80	7.56	0.41	0.33	1.03	0.71	251.4	211.7	18.41	21.11	219.1	191.3
T_7	7.84	7.49	0.41	0.32	1.02	0.93	251.0	211.4	22.26	18.10	218.7	191.1
T_8	7.79	7.54	0.42	0.32	1.04	0.93	250.7	210.4	18.14	20.49	218.9	190.7
T_9	7.70	7.46	0.32	0.31	0.95	0.70	247.3	209.4	21.60	15.42	207.8	179.9
SEm±	0.04	0.03	0.004	0.02	0.01	0.13	0.87	0.65	0.35	0.09	0.22	0.31
CD @5%	N/A	N/A	0.01	N/A	0.03	N/A	2.65	1.97	N/A	0.28	0.66	0.96
CV %	0.99	0.77	1.67	14.64	1.76	2.49	0.60	0.53	2.85	0.90	0.71	0.29

3. Results and discussion

Soil pH showed non-significant variation between two farming systems (Agroforestry system and open condition) in both 0-15 and 15-30 cm layer (Table 1). Agroforestry system showed significantly different values for soil EC compared to sole cropping. For soil organic carbon percentage, all the treatments differed significantly from control T_9 (0.95%) and under agroforestry, values ranged from 1.02 to 1.07%. Highest nitrogen content was present under agroforestry system compared to open farming. There was no significant difference of available phosphorus between open and under agroforestry system at 0-15 cm, but significant difference was found at 15-30 cm. The maximum available phosphorus recorded was in T_2 (21.69 kg/ha) followed by T_4 (21.54 kg/ha). Available soil potassium (kg/ha) showed significant variation between open farming and poplar-based agroforestry system.

5.20/T_5-106

Phyto-sociological Analysis of Waterlogged Saline Lands of Indian Trans-Gangetic Plains

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Keywords: Saline soil, diversity index, vegetation, grasses, water logging

1. Introduction

Introduction of canal network with excessive use of ground water without proper drainage systems in Trans Indo-Gangetic plains lead to waterlogging and secondary salinization, posing a grave threat to the major grain basket area of the country. Tree based approaches are ecologically and economically sound in managing such lands with other benefits of addressing climate change and providing ecosystem services. Flora identified through phyto-sociological approaches is beneficial to draw the comprehensive bio-remediation management plan for waterlogged saline soils.

2. Material and methods

Managed and abandoned waterlogged saline sites were marked to draw the vegetative comparative analysis through Quadrat Approach.Vegetation data were analyzed by tabular comparison using successive approximation method. The Relative Value Index (RVI) for shrubs/herbs/annuals and biodiversity indices was drawn as per the procedure laid by Misra (1968) and Shannon-Wiener (1963) & Simpson (1949), respectively.

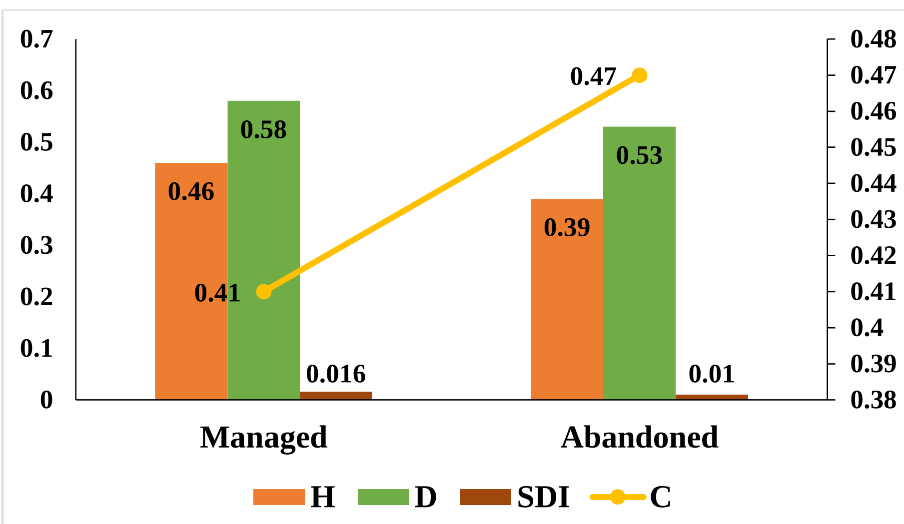

Fig. 1. Phyto-sociological indices (H-Shanon Weiner, D-Simpson diversity, SDI-Species diversity and C-Simpson index) of waterlogged saline sites

3. Results and discussion

Both the sites showed differential diversity index to each other. The managed sites were dominant with *Eucalyptus* plantations in block and boundary arrangement. Whereas, the abandoned sites did not show any specific pattern of tree component but only *Prosopis juliflora*was seen in scattered form accompanied by low values shrubs and grasses. Managed sites gave higher values of Shanon (0.46), Simpson (0.58) and species diversity (0.016) index than abandoned sites (Fig. 1). Crab grass was with highest relative density (52.96) and RVI (152.96) and minimum with elephant grass of 0.56 and 50.6 in managed site. Bermuda grass showed dominance with highest relative density (63.0) and RVI (163.0) and minimum with Red Tamarisk (14 and 114) in abandoned sites, respectively. The higher species diversity index (0.016) in managed than abandoned (0.010) sites inferred the higher degree of richness in flora. This can be interpreted that managed sites provide more ecosystem services than the abandoned sites. The study advocates that the higher species richness in managed waterlogged saline sites lead to the better use in terms of output on ecologically and economic perspectives.

References

Misra R 1968. Ecology Work book. Oxford and IBH Publishing Company Ltd, New Delhi, India.

Shannon CE and Wiener W 1963. The mathematical theory of communications. Urbana University, Illinois Press, USA.

Simpson EH 1949. Measurement of Diversity. *Nature* **163:** 688pp.

5.21/T_5-110

Fine Roots in Tropical Dry Deciduous Forest: Effect of Disturbance

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Keywords: Fine root, carbon storage, disturbance, root biomass, root density

1. Introduction

Understanding the effects of anthropogenic activity on plants can be aided by learning how fine root biomass and its distribution in the soil profile vary as a result of different disturbance intensities. The present study was conducted on three disturbed stands of Chhattisgarh's tropical dry deciduous forest. Biomass and carbon storage of fine roots were quantified for further understanding.

2. Material and methods

Belowground root (stand fine roots <5 mm diameter) was sampled from 5 monoliths (10 cm radius and 10 cm depth circular sample) from two successive depths at each site. Monoliths were washed with a fine water jet using 2 mm and 0.5 mm mesh screens. After drying at 80°C for constant weight, living and dead fine roots were weighed into two groups: a diameter of less than one millimetre and a diameter of one to five millimetres.

3. Results and discussion

The 51% of the fine root biomass and carbon storage was found in the surface soil layer of the highly disturbed stand, compared to an average of 66% and 55% in the moderately disturbed and undisturbed stands, respectively. Higher densities of fine roots in the surface soil layer were related to increased nutrient and water retention. Additionally, root turnover reduced as soil depth, root size, and degree of stand disturbance increased.

Table1. Mean fine-root biomass (g/m^2±SE) of tropical dry deciduous forest under disturbance gradience

Sites	0-10 cm				10-20 cm			
	>1mm		<1mm-5mm		>1mm		<1mm-5mm	
	Live root (g/m^2)	Dead root (g/m^2)	Live root (g/m^2)	Dead root (g/m^2)	Live root (g/m^2)	Dead root (g/m^2)	Live root (g/m^2)	Dead root (g/m^2)
Least Disturbed Forest	77.14 ±19.49	18.15 ±5.68	60.87 ±16.55	19.62 ±5.47	69.31 ±17.53	15.48 ±5.75	34.02 ±2.21	19.11 ±4.19
Moderately Disturbed Forest	165.24 ±51.26	29.88 ±12.05	34.91 ±11.38	13.63 ±4.41	73.89 ±25.59	13.57 ±5.33	31.28 ±6.61	23.76 ±7.45
Highly Disturbed Forest	60.26 ±7.18	14.52 ±4.77	16.18 ±5.79	19.49 ±7.65	52.11 ±8.27	14.08 ±4.83	22.61 ±6.26	28.03 ±13.71

The fine-root biomass in undisturbed, moderately disturbed, and highly disturbed stands was 314, 386, and 227 g m^2, respectively. The study revealed that the development and accumulation of fine roots differed based on species composition, tree density, and tree basal area. To restore these degraded tropical forests, the contribution of fine roots to developing soil organic matter and nutrient enrichment may be crucial in this location.

5.22/T_5-112
Forest Fire a Big Concern: A Case of Indian Forest

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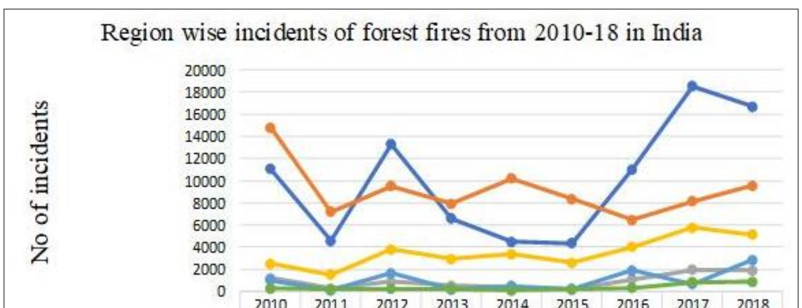
Keywords: Forest fire, fire measures, fire prone forest

1. Introduction

Forest fires cause large scale destruction of forest resources and biodiversity in the country every year. In recent years, there have been spurts in the number of forest fire incidents which is a cause of serious concern for all. Forest fires in our country are largely of anthropogenic origin and therefore preventable to a large extent. Apart from public awareness and their participation in controlling forest fires, use of all modern technological options particularly of geospatial technologies for prevention, detection, early warning, firefighting and damage assessment should be employed under a scientifically prepared forest fire management plan. This paper discusses forest fire prevention and management and underscores the need for better fire prevention practices and a well-equipped and trained workforce to fight fires.

2. Material and methods

Literature on the forest fire was gathered through online web-based search engines using keywords such as forest fires, wildfires, causes and impacts of forest fire, increasing instances of forest fire in India. Search was made reviewed for highly prone areas of India, synoptic use of remote sensing in forest fire detection and prevention, mitigation strategies. All the collected information obtained through research papers and articles, various reports was formulated and analysed using diagrammatic representation for further study. The published information had been based on secondary observations including recent data of 2021-22.



	2010	2011	2012	2013	2014	2015	2016	2017	2018
Central States	11063	4576	13299	6609	4476	4349	11002	18554	16705
North Eastern States	14778	7205	9531	7909	10203	8342	6472	8124	9557
Northern States	1219	295	881	551	383	188	1102	1953	1922
Southern States	2526	1536	3780	2949	3379	2609	3996	5764	5136
Western Himalay States	1010	98	1641	176	485	242	1917	659	2875
Western States	296	188	230	257	128	207	328	834	864

Source: MoEFCC

3. Results and discussion

It is revealed from the fig 1 that in the last 10 years, the Central Indian states has experienced highest number of forest fire incidents in 2017, which accounts for 40% rise in fire incidents. Not far behind, the North Eastern states where shifting cultivation is still prevalent account for 36% of the incidents. On the other hand, the Southern states shows increasing number of fire incidents from 2011-12, which accounts for 14% rise. The Western states, Northern states and Himalayan states shows least number of fire incidents as compared to Central and Northeast region. Forests of the central and Northeast India regions together accounts for 76% and are the most vulnerable areas to forest fires. As per the analysis of this data, it is concluded that the preventive forest fire measures are more important in combating forest fires, followed by post fire management practices. Further studies are required to analyse the pattern and trends of forest fire in India and factors responsible for high forest fire incidences in high fire prone forest areas to understand the causes of frequent fires, so that specific micro level plans can be prepared for controlling forest fires.

5.23/T_5-118

Natural Resource Management through Watershed Management Programme with special reference to Yavatmal district

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Keywords: Watershed, irrigation, water level, human animals conflicts

1. Introduction

Recently World Bank sign loan agreement of 115 million dollar to implement rejuvenating watershed for agriculture resilience through innovative development (REWARD) project in India. It boosts climate resilience and enhance efficiency of natural resources. Management of land, forest and resources without impairing the local wildlife have contributed to conservation of natural resource through minimizing over exploitation of natural resources.

2. Material and methods

The data is collected from primary sources through a questionary framed according to the objective of the study. The data was collected individually with own observation on the field of watershed management programme. Secondary sources such as literature available about WMP used to analyze the primary data (Varhade 2020). Sampling method is used to collect samples from Ner, Babhulgaon, Pandharkawada and Yavatmal tehsil of Yavatmal district, Maharashtra.

3. Results and discussion

Effective implementation of WMP through Forest Protection Committee to utilize natural resource judicially in the Yavatmal district. The success of WMP not only increase the flora and fauna nearby but also recorded reduction in the human animal conflict in the studied villages. A baby step of watershed management programme to conserve natural resource ultimately enhancing biodiversity in the forest.

Table 1. Effect of natural resources conservation through watershed management in Yavatmal

Resource	Parameter	Before WMP	After WMP
Water	Availability of water	Insufficient	Sufficient
	Depth of groundwater	20 Feet	15-10 feet
	Water for irrigation	4 months/year	6-8 months/year
	Water level of borewell	100 – 110 feet	50 feets
Forest	Fuelwood	Easily Available	Not Easily Available
	Wildlife near village	Tiger, leopard, bear, sambar blue bull	wild pig, dear, shakes
	Cases of human animals conflicts	Generally	Sporadically
	Collection of tendu leaves inside forest	yes	No

Reference

Varhade P 2020. Socio-Economic and Ecological impacts of watershed management in Yavatmal district of Maharashtra. *M.Sc.* Dissertation, Forest Research Institute deemed to be University Dehradun, India.

5.24/T_5-120

Soil Organic carbon Stock and Management Indices in Relation to Diversified Land use and Soil Depths in the sub-humid Southern Plains of Rajasthan, India

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Keywords: Land use systems, soil depth, soil carbon stock, agroforestry, grassland

1. Introduction

The proportional differences in soil organic carbon (SOC) and their management indices under different land changes are of significance for understanding the process of aggregation and soil carbon sequestration mechanisms. Land use changes from grassland and natural forest land use to cultivated lands led to a decline in SOC status resulting in low agricultural productivity, which ultimately affect the livelihood security of the farmers society. Soils are the largest terrestrial active sink for atmospheric carbon accumulation and have the potentials to mitigate the effect of global warming.

2. Material and methods

This study attempted to appraise the effect of different land use changes and soil depths on carbon sequestration and management indices under sub-humid southern plains of Rajasthan. Six dominant land-use systems: barren, agricultural, agri-horticulture, horticultural, grass, and natural forest were selected for a concise study. A total of 120 composite soil samples [6-LUSs, 4- soil depths (0-20, 20-40, 40-60, and 60-80 cm), and five replications] were collected for laboratory analysis. The two-way analysis of variance was used to test the effect of different LUSs and soil depths on SOC and essential properties with carbon management indices of soil.

3. Results and discussion

The results of the study showed that the total-SOC stock was influenced significantly by different land use systems (LUSs), and soil depths. The mean total-SOC stocks varied from the lowest value of 11.31 Mg ha^{-1} in barren land use to the highest value of 39.05 Mg ha^{-1} in natural forest land. On comparing the mean values under different LUSs, the total-SOC stock increased by 54.38, 59.62, 81.12, 61.94, and 94.90 per cent, respectively in the case of agricultural (17.46 Mg ha^{-1}), agri-horticulture (21.72 Mg ha^{-1}), horticultural (28.93 Mg ha^{-1}), grassland (29.23 Mg ha^{-1}), and natural forest (39.05 Mg ha^{-1}) LUSs as compared to barren land use (11.31 Mg ha^{-1}). The main effect of soil depth showed that total-SOC stock tended to decline with soil depths as it reduced from 33.38 Mg ha^{-1} in 0-20 cm soil depth to 16.88 Mg ha^{-1} in 60-80 cm soil depth. A comparative study of cumulative (0-80 cm soil depth) total-SOC stocks (fig1) under different LUSs, revealed that the natural forest land use contained about 156.80 Mg ha^{-1} in the first 0-80 cm soil control section followed by grassland (118.09 Mg ha^{-1}), horticultural (115.71 Mg ha^{-1}), agri-horticulture (86.88 Mg ha^{-1}), and agricultural (69.86 Mg ha^{-1}) LUSs whereas, lowest in the barren (45.24 Mg ha^{-1}) land use. Irrespective of different LUSs, the total-SOC stocks were decreased with soil depths, accordingly on an average nearly, 32 to 39 per cent SOC stock of the cumulative total- SOC stocks were found in the surface soil control section (0-20 cm) only.

Further, the study revealed that the LUSs in which trees were the main component, the lower soil depths contributed significantly higher in total SOC stocks as compared to the non-tree land use system. It indicated that the depth distribution of SOC was affected by different LUSs, which may influence the potential nutrients supply to the agricultural crops and plants. The CMI was highest under the forest land use system (230.36±4.13) and lowest in barren land use (54.60±4.26). The result of this study implies that consistent cultivation without appropriate land-use management practices in the cultivated LUS aggravates the deterioration of soil organic carbon and essential soil parameters. These results suggested that restoration of barren and agricultural lands into horticultural, agri-horticulture, and grassland-uses consequently decreased soil disturbance which could be an effective strategy for improving or maintaining the soil quality and sustainability in the study area that ultimately improve the livelihood security of the farmers.

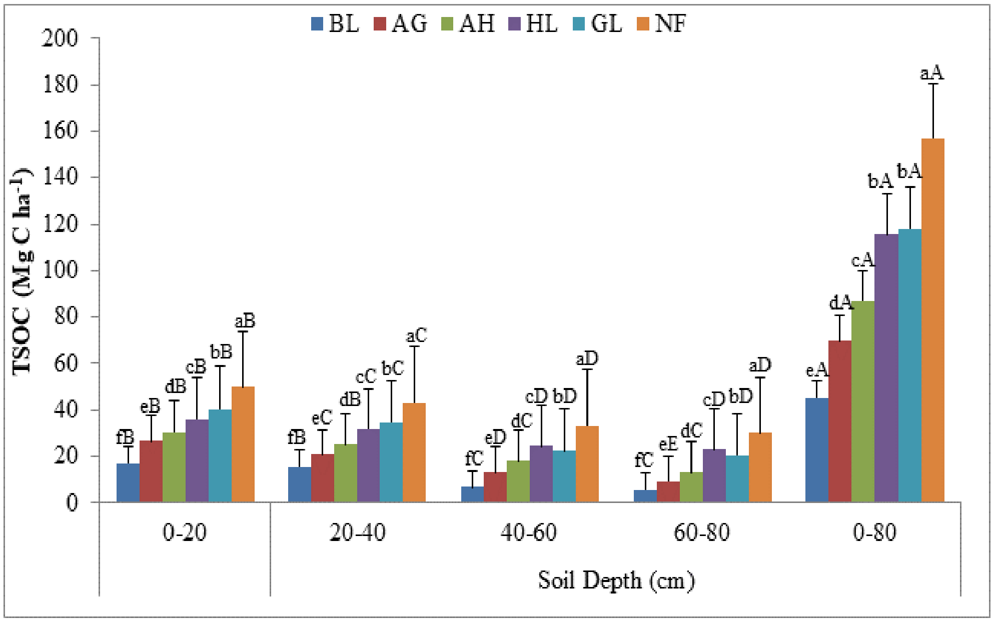

Fig. 1. Total soil organic carbon (TSOC) stocks (Mg ha^{-1}) in the 0-20, 20-40, 40-60, 60-80 cm and cumulative of 0-80 cm soil layers for six land uses (Barren land=BL, Agricultural= AG, Agri-horticulture=AH, Horticultural=HL, Grassland=GL and Natural forest land =NF). Vertical bars for each column indicate standard error of mean. Mean of different land use followed by the different lowercase letter (a-f) and means in the different layers followed by the different capital letter (A-E) are significantly different ($p<0.05$)

5.25/T_5-125

Floristic Diversity of Sacred Groves

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Keywords: Biodiversity, sacred groves, conservation, wasteland

1. Introduction

Sacred groves are the tracts of virgin forests that are left untouched by the local inhabitants and are protected by the local people due to their culture and religious beliefs. They are repositories of our rich biodiversity and are also the last bastion where the rich culture and the customs of the indigenous people are still preserved.

2. Material and methods

This paper is the review work based on published and technical reports related to sacred groves, present status of sacred groves in India with reference to Maharashtra, their importance for general wellbeing of ecosystem, major threats to their survival and majors to be taken for their conservation.

3. Results and discussion

In India sacred groves are found all over the country and abundantly found around Western Ghats. According to experts the total number of sacred groves ranges from 100000 to 150000. Maharashtra constitute wide range of sacred groves it nearly covers 14 districts of Maharashtra. Whereas Sindhudurg district has highest area (1892.83 ha) covering 1499 sites. The biodiversity of sacred groves is facing serious destruction because due to change in biotic and abiotic composition and conservation of forest land into wasteland. Legislative action along with general awareness among communities will lead to conservation of this rich heritage of India.

5.26/T_5-136

Feasibility of *Schizostachyum pergracile* in Gravity Drip Irrigation in Water Scarce Forested Watersheds of South Gujarat

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Keywords: Bamboo, drip irrigation, coefficients, friction loss, pressure discharge.

1. Introduction

Drip irrigation is "the slow, frequent application of small volumes of irrigation water to the base or root zone of plants". Although, drip irrigation system is very efficient, but use of poly vinyl chloride or high-density poly-ethylene makes the entire system costlier. Bamboo which is classified as a 'non-timber renewable forest product' could be used as a substitute for the PVC pipes.

2. Material and methods

Experimental set up was installed by cleaning the area, with six different treatments. T1; medi-infusion tube emitters, bamboo micro tube of 0.3 cm, 0.4 cm, 0.5 cm and 0.6 cm (T2, T3, T4, T5) and T6: PVC pipe lateral with emitters. Main pipe and lateral pipe glued together by mixing bamboo dust and adhesive in equal proportion. Extra coating of bondtite adhesive used for increased durability. Motor pump setting, used for water. The discharges were measured at 1.3, 1.4 and 1.5 kg cm^{-2} pressure.

3. Results and discussion

At the pressure of 1.3 kg cm^{-2} that gives the best coefficient of uniformity (CU) the maximum discharge was for treatment T5 at 1.4 kg cm^{-2} the maximum discharge was for the PVC pipe dripper (T6) and 1.5 kg cm^{-2} the maximum discharge was for treatment T4.

Table 1. Coefficient of uniformity (%), coefficient of variation (%), friction loss (m), average emitter discharge (l/hr), emitter exponent (x) among various treatments

Treatment	CU (%)			CV (%)		
	1.3	1.4	1.5	1.3	1.4	1.5
T1	89.77	88.40	87.99	0.10	0.15	0.14
T2	54.63	52.29	56.15	0.52	0.59	0.65
T3	51.21	66.86	50.89	0.52	0.63	0.59
T4	58.89	60.00	56.35	0.62	0.48	0.25
T5	81.59	69.25	56.35	0.36	0.25	0.55
T6	96.24	90.46	90.38	0.05	0.05	0.04

Table 1. Contd……

Treatment	Hg (m)			Average emitter discharge (l/hr)			Exponent (X)
	1.3	1.4	1.5	1.3	1.4	1.5	
T1	0.009	0.012	0.015	1.17	1.56	1.28	2.030
T2	0.009	0.012	0.015	3.15	2.61	0.52	12.88
T3	0.009	0.009	0.012	5.81	2.95	12.34	10.12
T4	0.009	0.009	0.012	11.48	7.84	18.68	6.039
T5	0.009	0.012	0.015	14.21	8.01	8.42	6.169
T6	0.006	0.006	0.009	7.94	8.28	2.44	0.886

The lower value of emitter exponent x (0.886) was observed in PVC pipe dripper indicating its lower sensitivity to flow rate with change in pressure when the pressure applied increased the friction loss in laterals increased. Coefficient of uniformity of the system was in the range of 50-96 %. 1.3 kg cm^{-2} is the best operating pressure for highest CU. T6 showed highest CU followed by T1 (89.77 %) and T5 (81.59 %).

5.27/T_5-137

Status, characteristics and factors affecting roadkills on NH-64: The Dandi Path, Navsari, Gujarat, India

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Keywords: Roadkill, linear infrastructure, development, reptiles, amphibians, mammals, conservation

1. Introduction

Development of the road network is a human developmental activity affecting wildlife negatively. Roads affect wildlife in direct and indirect ways. Direct effects involve deaths through vehicular traffic. Road construction and widening can lead to habitat destruction and fragmentation and severely impact species that used to avoid the road edge. Roads also restrict the movement of the species across the road, known as the barrier effect, and divide areas in the temporary island, especially during high vehicular activity. The barrier effect also reduces the gene flow, which could negatively affect the species' population size.

2. Materials and methods

Sampling of road kill was carried out from October 2021 to April 2022 on the road from Eru Char Rasta to Dandi Sea Coast, covering a distance of 14 km. While sampling, going towards Dandi, one side of the road was sampled, and another side was sampled while coming back. Data recorded while encountering roadkill include species names, dates, and broad habitat types. To assess site-specific factors affecting roadkills, we followed a used-unused sampling design where each kill was treated as a used location, and a random location was treated as an unused location. We considered five variables: canopy cover, shrub cover, ground cover, distance from the road edge, and distance from human habitation. Canopy cover, shrub cover, and ground cover were quantified on a 0- 100 scale by laying down a kill cantered plot of a 20 m radius (Chaudhary et al 2020). The distance of the kill from the road edge was quantified using a measuring tape, while the distance of the kill from human habitation was quantified by measuring the distance of the nearest house using a laser range finder. Further similar variables were collected at a random location on roads and considered as absence points of kills.

3. Results and discussion

A total of 336 kilometres of roads were monitored during the survey, resulting in roadkill of 70 individuals of 15 species, all of which were under the least concern category (Table 1). Out of 70, the maximum number of individuals belongs to reptiles (27), followed by amphibians (23) and mammals (20) ($\chi^2 = 1.04$, df = 2, $p<0.05$). The overall kill rate (Individual killed per kilometre) during the study period was 0.48. The highest kill rate was observed for reptiles, *i.e.,* 0.08, followed by amphibians, *i.e.,* 0.06, and mammals, i.e., 0.05. The maximum number of kills found during the month of March (24), followed by February (14), April (13), October (9), December (5), November (3), January (2) ($\chi2$ =36, df = 6, $p<0.05$). Maximum roadkills were found in the agriculture land (28), followed by human habitation (16), orchard (16), wetland (8) and pond (2) ($\chi2$ = 27.41, df = 4, $p<0.05$). Among reptiles, the highest number of kills were of common Garden lizard (*Calotes versicolor*) (15), followed by checkered keelback snake (*Xenochrophis piscator*) (4), rat snake (*Ptyas mucosa*) (4), common kukri snake (*Oligodon arnensis*) (1), Indian cobra (*Naja naja*) (1), wolf snake- Lycodon (1) and green vine snake (*Ahaetulla nasuta*), (1) ($\chi2$ =40.70, df = 6, $p<0.05$) (Table 1). Among amphibians' the highest number of kills was of the Common frog (*Rana temporaria*) (11), followed by the Common Indian toad (*Duttaphrynus melanostictus*) (7), Unidentified species, and Indian skittering frog (*Euphlycti scyanophlyctis*) (1) ($\chi2$ = 9.48, df = 3, $p<0.05$). Among mammals' the highest number of roadkill was of five striped squirrel (*Funambulus pennantii*) (8), followed by common tree shrew (*Tupaia glis*) (6), Indian Gerbil (*Tatera indiaca*) (4) and house rat (*Rattus rattus*) (2) ($\chi2$ =4, df = 3, $p< 0.05$). A total of eight models performed best (ΔAIC<2) and consisted of all habitat variables, i.e., canopy cover, shrub cover, ground cover, distance from the road edge, and distance from human habitat. Model averaging found that shrub cover (b=0.14± 0.95), ground cover (b= 0.58±0.86), distance from road edge (b=1.62±1.11), distance from human habitation (b= 0.51±0.42) were positively associated with kill sites, while canopy cover (b= -1.23±1.16) was negatively associated with the kill sites. Model validation analysis found an accuracy of 88 % and sensitivity of 89 %, which depicts the high accuracy of the best model used to evaluate the factor affecting kill sites.

Reference

Rohit Chaudhary, Nazneen Zehra, Azra Musavi and Jamal A. Khan. 2020. Evaluating the effect of ecological and anthropogenic variables on site use by sympatric large carnivores in Gir protected area, Gujarat, India. *Wildlife Biology* wlb.00696 doi: 10.2981/wlb.00696

Table 1. List of roadkill species found during the survey

Sr.no	Class	Common name	Scientific name	IUCN Status	Number of Individuals killed
1	Reptiles	Common Garden Lizard	*Calotes versicolor*	Least Concern	15
2		Checkered Keelback Snake	*Xenochrophis piscator*	Least Concern	4
3		Green Vine Snake	*Ahaetulla nasuta*	Least Concern	1
4		Indian Cobra	*Naja naja*	Least Concern	1
5		Common Kukri Snake	*Oligodon arnensis*	Least Concern	1
6		Rat Snake	*Ptyas mucosa*	Least Concern	4
7		Wolf Snake	*Lycodon aulicus*	Least Concern	1
8	Amphibians	Common Forg	*Rana temporaria*	Least Concern	11
9		Common Indian Toad	*Duttaphrynus melanostictus*	Least Concern	7
10		Unidentified	Unidentified	Unidentified	4
11		Indian Skittering Frog	*Euphlyctis cyanophlyctis*	Least Concern	1
12	Mammals	Five Striped Squirrel	*Funambulus pennantii*	Least Concern	8
13		Common Tree Shrew	*Tupaia glis*	Least Concern	6
14		Indian Gerbil	*Tatera indica*	Least Concern	4
15		House Rat	*Rattus rattus*	Least Concern	2

5.28/T$_5$-139

Evaluation of Air Pollution Tolerance Index of Tree Species in Jhansi city of Uttar Pradesh

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Keywords: Air pollution, trees, chlorophyl content, ascorbic acid

1. Introduction

According to the World Health Organization (WHO), air pollution causes nearly seven million deaths worldwide each year. The death rate from air pollution is found higher in cities than in rural areas. Trees growing in urban area play important role in maintaining ecological balance by cycling of nutrient and gases (Karthiyayini et al 2005). They reduce air pollution by impingement, absorption and accumulation of air pollutants in their leaves. Plants pollution tolerance capacity varies from species to species.

2. Material and methods

The study was carried out on nine trees species namely *Cassia fistula, Pongomia pinnata, Azadirachta indica, Ficus benghalensis, Ficus religiosa, Nerium indicum, Delonix regia, Dalbergia sissoo* and *Holoptelia integrifolia* found growing in Jhansi city. Leaf samples were collected from above 2 meter height from the trees located in highly populated areas of Jhansi city (railway station, bus stand, and Jhansi zone of Kanpur highway and were analyzed for the parameters like total chlorophyll content, ascorbic acid content, relative water content and leaf extract pH. These tests were also performed on the samples collected from the trees located at RLBCAU Campus and the results were compared. The data generated was subjected to the statistical analysis using SPSS software 16.0.

3. Results and discussion

In this study, the Air Pollution Tolerance Index (APTI) of nine major tree species of the Jhansi city was compared their APTI with the same species of the trees found in the campus of Rani Lakshmi Bai Central Agricultural University (RLBCAU), Jhansi (Table 1). The ascorbic acid content of the tree species varied from 0.26-3.94 mg/g under polluted sites and 0.009 to 2.56 mg/g under controlled conditions. Total chlorophyll content varied from 0.728 to 2.208 mg/g. Data pertaining to relative water content varies from 59.69-84%. APTI was recorded highest (10.30) in in the leaf samples of *Cassia fistula* collected from both the studied sites. The leaf area of trees species was decreased under the urban conditions compared to RLBCAU, campus and the highest size difference was obtained for *Nerium indicum*. the study has similar findings with Walia et al (2019) conducted study on tree species growing in NH-22 in Himachal Pradesh.

Table 1. Air Pollution Tolerance Index of trees grown in polluted site and control site in Jhansi city

Plant species	Ascorbic acid (mg/g)		Total chlorophyll content (mg/g)	
	Polluted site	Control site	Polluted site	Control site
D. sissoo	0.2670 ±0.082	0.009±0.0001	1.98±0.12	2.54±0.0003
C. fistula	3.9383 ±1.152	2.56±0.02	2.03±0.12	2.56±0.0002
F. religiosa	0.4227 ±0.125	0.1485±0.001	1.08±0.08	2.11±0.0003
F. benghalensis	0.6177 ±0.164	0.315±0.003	0.73±0.06	1.95±0.0004
N. indicum	0.5425 ±0.163	0.36±0.01	1.15±0.01	1.53±0.0002
D. regia	0.9562 ±0.262	0.736±0.005	1.62±0.01	2.19±0.0003
H. integrifolia	1.009 ± 0.263	0.764±0.001	1.83±0.08	2.22±0.0002
P. pinnata	0.3285 ±0.077	0.2275±0.0001	1.70±0.01	2.03±0.0002
A. indica	2.0247 ±0.583	1.7 ±0.03	2.21±0.12	2.88±0.0001

Table 1. contd……

Plant species	Leaf extract pH		Relative water content (%)		APTI	
	Polluted site	Control site	Polluted site	Control site	Polluted site	Control site
D. sissoo	6.93±0.006	6.49± 0.03	69.7 ± 0.29	63.48±1.63	7.21	6.36
C. fistula	6.33±0.090	6.1 ±0.02	70.07±0.29	66.78±1.64	10.30	8.90
F. religiosa	7.75±0.102	6.93 ±0.04	84 ± 0.31	56 ±1.63	8.77	5.73
F. benghalensis	8.24±0.006	8.03 ±0.03	77.73±0.30	50.51±1.63	8.33	5.37
N. indicum	6.35±0.006	6.07±0.01	60.6±0.29	57.32±1.66	6.47	6.01
D. regia	6.38±0.004	6.11±0.04	60.86±0.29	53.67±1.68	6.85	5.98
H. integrifolia	7.46±0.040	6.98±0.03	69.15±0.29	64.3 ±1.63	7.85	7.13
P. pinnata	6.81±0.015	6.52± 0.02	71.6 ± 0.30	67.3 ±1.62	7.44	6.92
A. indica	6.79±0.052	6.16 ±0.03	59.69±0.30	46.5 ±1.63	7.79	6.19

The APTI of *Ficus religiosa* (8.77) and *F. benghalensis* (8.33) was second and third highest, respectively, and hence these tree species along with *Cassia fistula* can be excellent performers to mitigate air pollution in Jhansi city.

References

Karthiyayini R, Ponnamal NR and Joseph R 2005. Air pollution tolerance index of certain plants of Coimbatore ooty highways, near ITI area, Coimbatore, Tamil Nadu. *Pollution Research* **24**(2): 363-365

Walia K, Aggarwal R and Bhardwaj S 2019. Evaluation of air pollution tolerance index and anticipated performance index of plants and their role in development of green belt along national highway-22. *International journal of current microbiology and applied sciences* **8**(3): 2498-2508.

5.29/T_5-140

Eucalyptus Plantations: Effects on Soil Properties

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Keywords: Eucalyptus, plantation, soil properties, agriculture, agroforestry

1. Introduction

The physico-chemical and biological properties of soils are greatly influenced by the land use system. Eucalyptus is one of the most widely planted tree species in the world owing to its wider environmental adaptability and fast-growing nature. Though having significant economic contributions, many controversies has been raised across the world as it has negative impact on ecology and soil properties (Tererai et al 2014). Therefore, present trial was carried out to study the effect of Eucalyptus plantations on soil properties under South Gujarat condition.

2. Materials and Methods

Two Eucalyptus plantation sites, one in Navsari Agricultural University (NAU) campus, Navsari and another at farmer's field, nearby NAU campus having same plantation year (2017) were selected for the present experiment. Soil samples were collected twice in the year at pre-monsoon (June) and post-monsoon (October - November) during the years of 2019, 2020 and 2021 at a depth of 0 -15 cm and 15 -30 cm from each selected site. Pertinent properties of soils *viz.* Soil pH (1:2.5), Soil EC (1:2.5), SOC, available N, P_2O_5 and K_2O as well as bacterial and fungal populations were determined in the laboratory. Subsequently, the obtained data were subjected for statistical analysis by using RBD. In statistical analysis, the data were grouped into Locations (L_1-NAU field, L_2- Farmers field), Plantations (E_1 - Eucalyptus plantations, E_2 - Nearby agricultural field), Seasons (M_1 - Pre-monsoon, M_2 - Post-monsoon) and Depths (D_1- 0 - 15 cm, D_2- 15 - 30 cm) and they were considered as treatments.

3. Results and discussion

The pooled results revealed that soil pH was found significantly lower under Eucalyptus plantation (7.61) as compared to nearby agricultural field (8.47). In contrast, EC was recorded numerically lower in the soils of Eucalyptus plantation but, failed to exert significant effect when compared with agricultural field. As far as the soil fertility is concerned, SOC (0.67 %), available P_2O_5 (61.4 kg ha^{-1}) and available K_2O (665.6 kg ha^{-1}) were recorded significantly higher under the soils of Eucalyptus plantation as compared to nearby agricultural field with the corresponding values of 0.54% and 55.8 kg ha^{-1}and 616.8 kg ha^{-1} respectively. Whereas, the availability of N did not influence significantly due to plantations. The results pertaining to microbial population also revealed that bacterial and fungal populations were recorded significantly higher under Eucalyptus plantations as compared to agricultural field. With regards to seasonal influence of soil properties, soil pH and EC were found decreased significantly after the monsoon when compared with the results of pre-monsoon season. The results also revealed that SOC (0.61 %), available N (225.8 kg ha^{-1}), available P_2O_5 (61.7 kg ha^{-1}) and bacterial (3.43 x 10^6 cfu/g soil) and fungal (0.80 x 10^3 cfu/g soil) populations were recorded significantly higher when soils analyzed in post-monsoon season as compared to pre-monsoon season while, the availability of K_2O recorded significantly higher in pre-monsoon season over the post-monsoon. Investigation emphasized that Eucalyptus block plantation (five year) not only reduced the soil alkalinity; but, also improved the SOC and avail. P_2O_5 and K_2O of the soil.

References

Tererai F, Gaertner M, Jacobs SM and Richardson DM 2014. *Eucalyptus camaldulensis* invasion in riparian zones reveals few significant effects on soil physico-chemical properties. *River Research and Applications* **31**(5):590-601

5.30/T_5-143

Agroforestry Land Use Advocated to Climate Change Mitigation by Carbon Neutrality

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Keywords: Climate change, carbon farming, CO_2 emission, CO_2 evolution, carbon neutrality

1. Introduction

Agroforestry as a high carbon ecosystem with sustainable crop production is well recognised for mitigating climate change by reducing greenhouse gas (GHGs) and regulates agro-ecosystem services. The study was carried out at Agroforestry Research Centre, GB Pant University of Agriculture and Technology, Pantnagar.

2. Material and methods

Carbon dioxide (CO_2) emission was estimated by using cool farm tool (CFT) i.e., based on total CO_2 emission through cultural operations (tillage/harrowing) and inputs (application of synthetic fertilizer, insecticide, irrigation, transportation) given to the medicinal and aromatic crop *Mentha arvensis* under *Populus deltoides* based silvi-medicinal system.

3. Results and discussion

Total CO_2 emission was 539.56 kg ha^{-1} out of which maximum CO_2 emission was estimated for synthetic fertilizers. Total CO_2 emission through mint crop cultivation contributed by urea (339.547 kg or 63%), NPK 12:32:16 (132.5 kg ha^{-1} or 24%), irrigation (34.90 kg ha^{-1} or 6%), tillage (11.2 kg ha^{-1} or 2.1%) insecticide (10.2 kg ha^{-1} or 2%) and transportation (2.91 kg ha^{-1} or 1%). After 90 days of incubation period total evolved CO_2 under agroforestry system and open farming system was 94.25 mgC and 55.80 mgC, respectively. Kosi variety produced maximum herbage yield and thus it stored maximum carbon under both farming systems. During the experimental period poplar trees stored 5.992 Mg C ha^{-1}. Sole mint crop stored more carbon. However, mint+poplar based agroforestry system stored more carbon and evolved more CO_2 thus, it reduces or balance the CO_2 emission and release more nutrients to the soil through mineralization process, respectively.

5.31/T_5-145

Imperishable Watershed Development using Remote Sensing and GIS

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Keywords: Geographic information system, morphological characteristics, remote sensing, watershed

1. Introduction

Government investments in five years plans require precise data on demand and supply of natural resources, social, economic and regional vulnerability to disasters. The assessments of the changes that have taken place in the land use pattern are needed to prepare a land use plan. The task of evaluation and planning has become easier with the advent of remote sensing and GIS. Actual field data along with remotely sensed data could help in scientific prioritization of watersheds.

2. Material and methods

In this study, nine micro watersheds belonging to 5B2F1C watershed of coastal Navsari were selected to monitor their spatial and temporal changes. The study focused on identifying the problem of each micro watershed which consequently helped in prioritizing the micro watersheds in which government investments could be made in order to initiate development work for welfare of coastal communities (Bhanderi 2016). The study was taken up with the objectives of characterizing, identifying major problems, assessing land use changes and prioritizing the selected watersheds.

3. Result and discussion

The morphological characteristics of the micro watersheds under study were identified. Stream order was found to be 3 in all the micro watersheds whereas total stream length and relief ranged from 7 km to 16 km and 9 m to 15 m respectively. Micro watershed 1C2 with ruggedness number 24.58 was found to be most prone to erosion compared to other micro watersheds. Drainage density varied from 0.84 in 1C1 to 1.62 in 1C2. The highest values of form factor, circulatory ratio and elongation ratio were 0.57, 0.85 and 0.86 in 1C1, 1C2 and 1C1 respectively. According to hydrological characterization, micro watershed 1C8 should get top priority followed by 1C4 and least priority should be given to 1C1. With respect to availability of water in form of water bodies and canal water supply, 1C3 required top priority whereas on the basis of soil and water parameters, 1C7 required top priority. 1C8 and 1C9 required top priorities based on their socio-economic condition. The overall priority showed that micro watershed 1C2 needed top priority followed by 1C3, 1C9, 1C8, 1C4, 1C1, 1C7, 1C5 and 1C6. This prioritization could be used by government departments, NGO’s and funding agencies while planning and executing projects to fulfill specific mandates. It was concluded that all the micro watersheds needed groundwater recharging to combat sea water intrusion and brackish water aquaculture should be avoided where it is possible to harvest rain water and cultivate sweet water fish. Evaluation and assessment of changes in watersheds over a period of time could help in rectifying the follies committed in the past and necessary steps could be taken in prioritized micro watersheds.

Reference

Bhanderi BN 2016. Study of Coastal Micro Watershed near Dandi. *M.Sc.* Thesis submitted to Navsari Agricultural University, Navsari, Gujarat.

5.32/T_5-154

Pterocarpus santalinus: An Overview on Propagation Techniques for its Conservation

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Key words: *Pterocarpus santalinus*, endangered, natural regeneration, micropropagation, germplasm

1. Introduction

Pterocarpus santalinus has a special status because of its multi-utilitarian features, endemic nature, and supreme technical qualities. Natural regeneration has major constraints. Propagation through seed is often very difficult because of a hard seed coat. Tissue culture has proved to be a promising technique. However, the members of family Fabaceae have been difficult to culture *in vitro* owing to their recalcitrant nature.

2. Material and methods

The secondary data collection method was used to gather information on the *P. santalinus*, the research data was reviewed from various sources; like review of literature, gazetteer, recent research papers, technical reports, discussion with experts and local people. The information was gathered on certain aspect like seed treatment, vegetative techniques, and micropropagation techniques and associated facts of *P. santalinus* for its performance which can be utilized for discussion regarding mass multiplication and conservation purposes. Further, the data was systematically arranged and analysis was done and conclusion was drawn.

3. Result and discussion

The review of literature revealed that seed propagation in *P. santalinus* is often very difficult because of a hard seed coat coupled with poor viability, whereas some authors observed that seeds pre-treated with GA_3 @ 500 ppm for 24 hours reported the best results of earlier sprouting (7.67days), higher germination (70.00%) and survival (63.33%) of seedlings (Patel *et. al*., 2018). However few studies reported in Table 1. revealed that the micropropagation system may be useful for clonal multiplication of *P. santalinus*, as recorded highest (88%) explants forming shoots with a maximum 10.4 ± 1.50 mean number of shoots per explants in response to the combination of BA and kinetin (0.1+1.0) at 1 mg/L growth regulators and turn ultimately is a source of propagules for use in afforestation programs and germplasm conservation (Arockiasamy, *et. al*, 2000). However, a reliable and efficient micropropagation protocol was developed through axillary shoot proliferation from cotyledonary nodes with significantly higher shoot multiplication rate. Whereas, comparative growth performance study of the tissue culture raised plants and seedlings, indicated that *ex vitro* rooting method was a more suitable for successful cloning of *P. santalinus*.

Table 1: Review of responses of seed treatments, vegetative propagation and micropropagation techniques in *P. santalinus*.

Treatment	Source	Response	Author
Seed treatment			
Pods incubated at 90 ^{0}C treated for a duration of 20 min and 15 min duration at 100 ^{0}C	Pods	Germination (84%)	Naidu (2000)
GA_3 @ 500 ppm for 24 hours	Pods	Germination (70%) and survival (63.33%) in 7.67 days first sprout	Patel et al (2018)
Leached pods (72 hours) were soaked in GA_3 (500 ppm) for 12 hours	Pods	Germination (88%) with reduced germination period from 53 to 14 days	Renganayaki *et al* (2020)

Vegetative propagation			
Grafting methods	Rootstock and scion	38.70 % graft success during March followed by 27.72 % during February	Kedharnath *et al* (1976)
Grafting methods	Stem cuttings	Graft takes only 26 % by *in situ* cleft grafting performed on 4yr, 7yr, and 10 year old stocks. Also retention of wavy grains in scion wood with a little higher bark thickness.	Reddy and Srivasuki (1990)
Methods of grafting	Stem cuttings	Oblique propagation method gave highest survival rate (90%) and lowest was in cut grafting propagation method (52.8%) in plastic green house.	Xiaonan *et al* (2019)
Micropropagation			
Response of growth regulators on explants sprouting	Shoot buds	Highest 88 per cent of explants forming shoots with maximum 10.4+1.50 mean No. of shoots per explants in response to combination of BA and kinetin (0.1+1.0) at 1 mg/L growth regulators after three weeks, while poor response was recorded in Zeatin	Arockiasamy *et al* (2000)
Seeds cultured within 1 week of harvest in different *in-vitro* mediums	Seeds	96% of *in-vitro* germination on Anderson medium without charcoal	Chaturani *et al* (2006)
Response of various treatments on explants survival	Shoot buds	70 per cent of nodal explants survived using ST+ AO (Serial transfer technique in combination with Antioxidants (250 mg/L ascorbic acid and 50 mg/L citric acid) followed by sole ST (59%) and sole AO (56%)	Ekambaranellore *et al* (2006)

References

Arockiasamy S, Ignacimuthu S and Melchias G 2000. Influence of growth regulators and explants type on *in-vitro* shoot propagation and rooting of red sandal wood (*Pterocarpus santalinus* L.). *Indian Journal of Experimental Biology* **38**: 1270-1273.

Patel HS, Tandel MB, Prajapati VM, Amlani MH and Prajapati DH 2018. Effect of different pre-sowing treatments on germination of Red sanders (*Pterocarpus santalinus* L. f.) in polyhouse condition. *International Journal of Chemical Studies* **6**(4): 162-165.

5.33/T_5-155

Experimentation of Seed Storage Packages to Retain Oil Content in Late Season Harvested Seeds of *Azadiractha indica* (A. Juss)

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Keywords: Omnipotent, mahoganies, sacred, kernel, desiccator

1. Introduction

Neem trees are omnipotent and distributed in a diverse agroecological range and large variations in morphological and biochemical characteristics. The kernels contain 40-50 percent of the oil. Neem seeds have constraints to retaining oil for a longer period. Therefore, experimented to evaluate the response of storage packages on the deviation of oil content in *Azadiractha indica* seeds collected in the late season.

2. Material and methods

During the fortnight of July, fresh neem fruits were collected, and within 24 hours de-pulped and cleaned. Even seed samples were air-dried and kept in shade and sunlight for 48–72 hours. Based on storage temperature, condition, and drying methods, eight storage packages were designed. Average oil content and its loss were recorded for ten months in each storage package at 30 DAT. The data were analyzed in a randomized block design with three replications.

3. Result and Discussion

Initial moisture and oil content in the seed lot was 20.00% and 42.88%. From Table 1, data revealed that the treatments were significant effects on the oil content at 30, 120, 210, and 300 DAT. It was found that the average loss of oil content ranges from 1.88 to 2.79 in the kernel at 300 DAT. The average oil retention was highest (95.42 %) in A2B1D2 whereas lowest in A2B1D1. It was concluded that seeds collected during fortnight of July, properly treated was effective under the storage package, and when sun-dried seeds were kept in cotton bags and stored under low temperature $2^0C \pm 2$ was able to minimize the loss of oil content up to 4.58 percent in the kernel.

Table 1. Effect of storage temperature, storage conditions and drying conditions on oil content in kernel of *A. indica*, of late season collected seeds.

Treatments (Storage Packages)	Oil content in kernel (%)									
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	210 DAT	240 DAT	270 DAT	300 DAT
A1B1D1	42.15	41.96	41.89	41.37	41.00	40.34	40.17	39.82	39.79	39.54
A1B1D2	42.11	41.93	41.82	41.26	41.05	40.74	40.19	40.05	40.08	39.98
A1B2D1	42.20	41.91	41.94	41.80	41.70	41.25	40.70	40.25	40.33	39.53
A1B2D2	42.12	42.03	41.81	41.75	41.63	40.83	40.79	40.18	40.10	40.02
A2B1D1	42.26	41.91	41.75	41.12	40.87	40.67	40.21	40.00	39.63	39.47
A2B1D2	41.08	41.24	41.25	40.71	40.86	40.23	39.87	39.49	39.27	39.20
A2B2D1	42.23	42.14	42.09	41.99	41.77	41.35	41.00	40.79	40.40	40.27
A2B2D2	41.51	41.51	41.10	41.03	40.94	40.47	40.07	39.90	39.37	39.15
SEM±	0.06	0.15	0.09	0.06	0.15	0.10	0.02	0.10	0.15	0.06
CD (5%)	0.17	NS	NS	0.17	NS	NS	0.06	NS	NS	0.17

5.34/T_5-159

Melia dubia Cav. cultivation in Gujarat, India: Research Development and Outreach

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Keywords: *Melia dubia*, agroforestry, spacings, sole plantations, paper and pulp, plywood

1. Introduction

Against the global average productivity of 2.1 m^3 $hectare^{-1}$ $year^{-1}$, the productivity of Indian Forest is only 0.5 to 0.7 m^3 $hectare^{-1}$ $year^{-1}$, while TOFs are producing nearly 3.06 cum per ha per year. In this backdrop, many efforts have been made to meet wood deficiency by implementing programmes and schemes oriented to supply sustain wood to various wood-based industries. Species like Eucalypts, Poplars, Acacias, Casuarinas, *etc*., have been introduced, and to some extent, raw material supply was assured. *Melia dubia* Cav., an important multipurpose tree, indigenous to Western Ghats region of India, and is common in moist deciduous forests of the Indian states. It is a short rotation species (Thakur et al 2021a) having multiple uses like very good raw material for ply and pulp wood, plywood industries, high-quality timber for various purposes (Parthiban et al 2019).

2. Material and methods

M. dubia is native species of Gujarat state and under Gujarat Government funded research project, research on candidate plus tree selections, multi-location progeny evaluations trials, investigations on its suitability as agroforestry, allelopathic propensity and bock plantations under varying spatial geometries, propagation protocols, as alternate feed source for livestock, *etc*. have been done in last decade.

3. Results and discussion

Over, almost one decade research divulged that there is good repository of superior genotypes in south Gujarat, multi-locations progeny trials pinned out that it can achieve more than 30 tonnes biomass per hectare in 5 years, local source have germination up to 30 per cent (Chauhan et al 2021) medicinal and aromatic, vegetable crops, pulses can be grown successful in agroforestry models (Thakur et al 2021a, 2021b), varying spatial geometries can be adopted to produce wood for various industries depending upon the dimensions required. Apart from its use in wood-based industry, it could be an alternate energy rich fee resource (both fruit as well as fodder) for live stocks. It has very good coppice ability and clonal propagation can be done through root sucker sections without sacrificing the selected plus trees (Thakur et al 2021c). Farmers in Gujarat have adopted this species and various paper-pulp and ply wood industries have now started using this species. Thus, the series of studies indicated that *M. dubia* is fast growing multipurpose tree species which can be success fully adopted in Gujarat with assured market.

References

Chauhan R S, Jadeja D B, Thakur N S and Jha S K. 2021. Variability in stone characters and early progeny performance of selected *Melia dubia* genotypes from northern western Ghats of India. *Indian Journal of Ecology*, 48(4): 1032-1038.

Parthiban KT, Chauhan SK, Jude SR (2019) Malabar Neem *Melia dubia*. Agrobios India, P 256.

Thakur N S, Hegde H T, Chauhan R S, Gunaga R P and Bhuva D C. 2021c. Root sucker technique for successful clonal multiplication of *Melia dubia* Cav. without sacrifice of mother tree. *Current Science*, 121(9): 1235-1237.

Thakur N S, Jilariya D J, Bhusara J B, Prajapati D R, Hegde H T, Chauhan R S, Gunaga R P and Bhuva D C. 2021b. Agroforestry with *Melia dubia* Cav. in western India. In: Ashok Kumar and Geeta Joshi (Eds), Recent Advances in *Melia dubia* Cav. BSMPS, Dehradun, India, pp. 259-266.

Thakur NS, Gunaga RP, Hegde HT, Chauhan RS, Bhuva DC, Bhusara JB (2021a) Development of biomass and volume models of *Melia dubia* Cav. for early establishment. Indian J Ecol 48(3): 698-701.

5.35/T_5-164

Comparative Chronological Trends of Biometric Gains and Carbon Mitigation Rate of Agroforestry Trees in Shallow Saline Situations of Semi-Arid Region

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Keywords: Agroforestry, saline soil, carbon mitigation, land degradation

1. Introduction

Ever increasing demand for good quality land and water resources in the domestic and industrial sectors has already generated interest in the utilization of degraded lands at large and especially salt affected areas. Use of degraded lands and poor-quality water represent an opportunity that can be exploited to increase production and productivity of problematic lands besides to bring the 26 m ha additional degraded lands under tree cover to achieve the land degradation neutrality by 2030 as per the commitment of Indian Government made in Delhi Declaration-2019 of UN CoP-14. With this backdrop, five tree species were evaluated to find out the growth and mitigative advancement of best one for greening shallow saline lands of semi-arid region.

2. Material and methods

The out-planting of *Eucalyptus tereticornis*, *Azadirachta indica*, *Dalbergia sissoo*, *Melia composita* and *Terminalia arjuna* was done in line geometry in uniform block of 4 x 2 m spacing under Stratified Random Sampling Design to observe the trends of biomass and mitigative carbon capture in shallow saline situations of semi-arid region. Sub-surface furrow planting method was adopted and the plantations were irrigated with saline water of ECiw 4 to 6 dS/m on need basis. The observations on survival and growth attributes were recorded after the completion of one growing period on annual basis in the month of October. However, the observations on biomass and mitigative carbon capture were made once after two growing seasons successively upto six year of plantation age.

3. Results and discussion

Performance rating based on establishment and growth parameters revealed that *Eucalyptus* gave highest value (2.49, 4.46 and 25.7) followed by *Azadirachta* (1.60, 3.30 and 17.2), *Dalbergia* (1.65, 3.16 and 10.5), *Melia* (1.45, 2.58 and 6.20) and *Terminalia* (0.83, 1.70 and 5.80) at two, four- and six-years aged plantations, displaying the potential of adaptability with tangible and non-tangible services of the planted trees in shallow saline situations with saline water irrigation (Fig. 1).

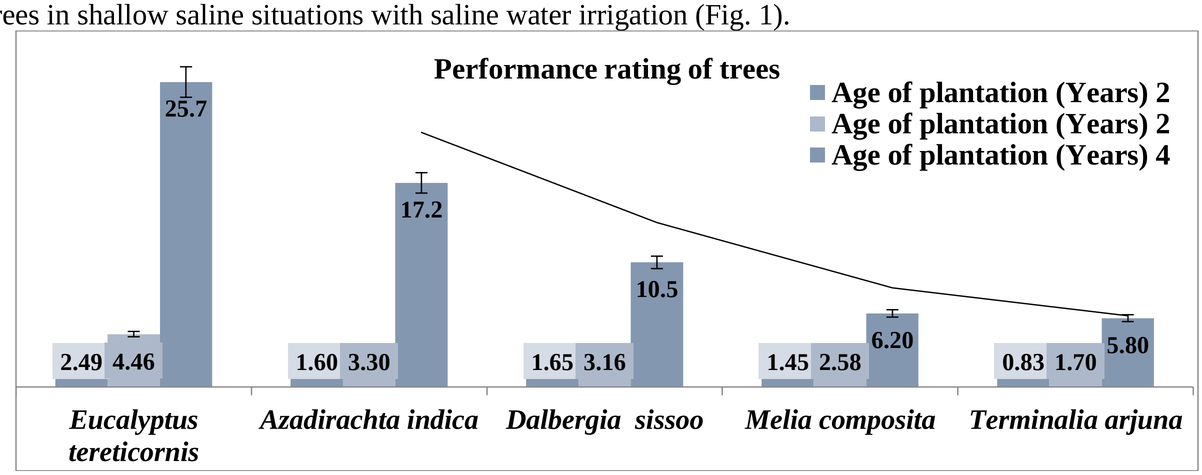

Fig. 1. Performance rating of trees against age gradations of 2, 4 and 6 years

Major chunk of biomass accumulation is towards above ground portion which was 81.8, 77.2 and 77.0 per cent than below ground at 2, 4 and 6 years of age, showed the reduction with the increase in the tree age. Carbon stock, Co_2^e, carbon sequestration rate and Co_2^emitigation rate was higher in *Eucalyptus* than the other tree species during age gradation of two, four and sixth year of progression. *Eucalyptus* gave highest CO_2e mitigation rate followed by *Dalbergia*, *Melia*, *Azadirachta* and *Terminalia*. Biomass allocation coefficients and growth efficiency attributes equally support the best performance of *Eucalyptus* in saline soils. *Eucalyptus* emerged as most potential tree species for planting in saline soils for higher biometric gains and mitigative potential. However, *A. indica*, *Dalbergia sissoo* and *Melia composita* can also be equally good for giving the potential option for ecological rehabilitation with socio-economic gains from sallow saline landscapes.

5.36/T_5-165

Natural Resource Conservation through Ecotourism Management Practices in Chhattisgarh

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Keywords: Ecotourism**,** wildlife, conservation, natural resource

1. Introduction

Ecotourism seeks to preserve the nature by supporting the local economy and encouraging greater adherence to customs and culture. Ecotourism and natural resource conservation shares a symbiotic partnership together. Under this mutually beneficial arrangement, ecotourism destinations profit from the preservation of high-quality natural resources through greater competitiveness, while the value of conservation of natural resources rises as these resources are acknowledged as the foundation of the ecotourism sector and the source of all economic advantages related to ecotourism.

2. Material and methods

Chhattisgarh is one of the greenest states in India, and the state's forests are well-known for their varied flora and wildlife. The wildlife population in Chhattisgarh is also exceptional, and the state has National Parks and Wildlife Sanctuaries that house some endangered animal and bird species. The study based on various literature reviews available data on internet journal article and related research papers.

3. Results and discussion

The resources that are found in nature but are not influenced by humans are known as natural resources. Natural resources may not have enough inherent worth to warrant conservation without ecotourism, and natural resources may experience a variety of negative externalities as a result of ecotourism. Ecotourism growth must support educational advancement and raise public understanding of the need of maintaining the local ecology together. The management of natural resources and the implementation of development plans must preserve ecological and environmental integrity. One of the most important ways ecotourism can be distinguished from other forms of tourism is through environmental education and interpretation, which is also the key to creating an enjoyable and fulfilling ecotourism experience also conserve the natural resources.

References

Bynum B Boley and Gary T Green 2016. Ecotourism and natural resource conservation: the ‘potential’ for a sustainable symbiotic relationship. *Journal of Ecotourism* **15(**1): 36-50

5.37/T$_5$-166

Floristic Diversity of Nani-Kakrad Wetland, Navsari, Gujarat, India – A Preliminary Survey

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Keywords: Flora, diversity, wetland, ecosystem

1. Introduction

Navsari, located near Arabian Sea is geographically an undulating terrain with various small and large rivers traversing and flowing into the Arabian Sea. As a result, it creates many tiny and large ponds. In Navsari, there is a large water body called the Nani-Kakrad wetland, which is flanked by numerous tiny tanks. It is one of the eight nominated national wetland locations that have been designated for conservation efforts. In order to create a baseline for the plant diversity in the Nani-Kakrad Wetland, the current study was carried out in 2018–2019 to enumerate aquatic and hydrophytic vegetation.

2. Material and methods

Stratified random sampling method was adopted on the selected grids for studying plant diversity. Field notebook was carried along for noting down morphological characters of plant along with photographs. The plant species were identified with available literature of Shah G. L. (1978) and Banerjee *et. al* (2002).

3. Results and discussion

Total of 130 angiosperm species spread across 42 families are documented from Nani-Kakrad wetland. Amongst them, different life forms of plant species like herb (42 spp.), shrub (15 spp.), trees (16 spp.), floating herbs (4 spp.), creepers (5 spp.), climbers (16 spp.) and Grasses (34 spp.) were reported. The flora of Nani kakrad represents 35 dicot families of and 7 monocot families. The most dominated families are Poaceae, followed by Malvaceae, Amaranthaceae, Euphorbiaceae and Fabaceae.

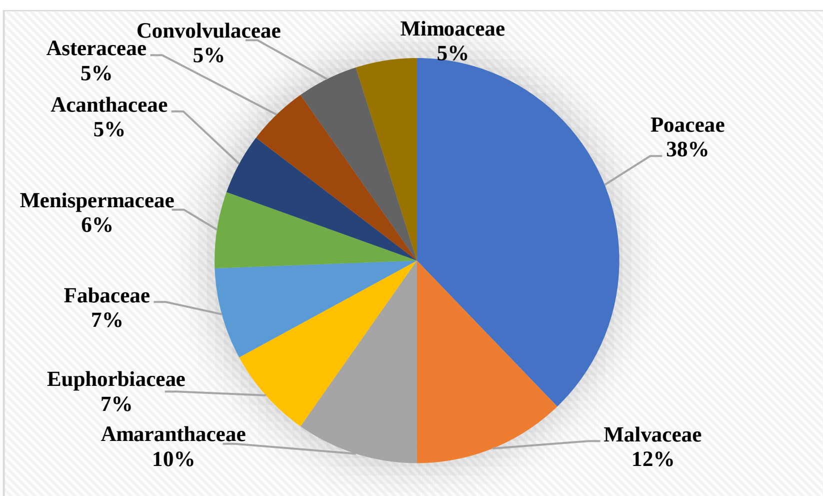

Fig. 1. Top ten Families of the Flora annotated in the wetland of Nani-Kakrad, Navsari, Gujarat

References

Banerjee LK R, Sastry RK and Ghosh D 2002. "Diversity *of Coastal Plants Communities in India",* Botanical Survey of India, Kolkata.
Shah GL 1978. *Flora of Gujarat State*, Vallabh Vidyanagar, Gujarat, India.

5.38/T_5-169

Soil Texture Variations in Different Horticulture-Based Agroforestry Systems in Valsad District of South Gujarat

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Keywords: Agroforestry, soil properties, fertility, fruit trees, vegetable crops

1. Introduction

This study is a testament to the fact that agroforestry practices can significantly contribute to the protection and conservation of our planet's land resources. Agroforestry systems have proven to be highly effective in providing benefits such as increased soil fertility, soil carbon storage, improved water retention, and enhanced biodiversity. We must continue to invest in these sustainable agricultural practices in order to protect our planet's valuable resources for generations to come. This is an eye-opening statistic and it shows just how important tree cover is to our agricultural lands. We need to be mindful of this and continue to find ways to increase tree cover as much as possible. There are many initiatives out there that are working towards this goal and supporting them can go a long way in making sustainable progress.

2. Material and methods

The present study was conducted in Valsad district of South Gujarat. The climate of South Gujarat is typically tropically characterized by fairly hot summer, moderately cold winter and warm humid monsoon. Generally, the monsoon in this region commences in the second week of June and ends in September. Most of the precipitation is received from the South-West monsoon, concentrating in July and August with an average annual rainfall of about 1431 mm. In the present study, total 18 farmer's fields, which representing horticulture-based agroforestry system was selected from 9 villages belonged to 3 Talukas of Valsad district of South Gujarat. Soil samples were collected from these farm fields. Representative soil samples were collected randomly from 0-15 cm and 15-30 cm depth from each prevalent horticulture-based agroforestry system. All the soil samples were labelled properly *viz.*, name of the farmer, village, location, depth and date of sampling and brought to the laboratory for further laboratory studies. After that, they were air-dried and ground to pass through a 2 mm sieve with wooden mortar and pestle and preserved processed samples for physical analysis with international pipette method.

3. Results and discussion

The data pertaining to variations in soil texture under different horticulture-based agroforestry systems are presented in Table – 1. By considering soil profile of 0 - 15 cm depth in Valsad district, the maximum clay content (57.52 %) was found in Mango + Turmeric based Horti - Tuber crops system, which was followed by Mango + Papaya based Mixed fruit crops system (54.30 %). Whereas, minimum clay content was reported in Mango + Sorghum based Horti - Pastoral system (26.13 %). Similar trend was also recorded in the soils of 15 - 30 cm depth in different agroforestry system. In the case of silt content at 0 – 15 cm soil depth, maximum silt content was recorded in the soils collected from Mango + Sponge gourd + Cowpea + Cucumber based Horti - Vegetable vine crops system (43.48 %) which was followed by Mango + Ivy Gourd Horti- Vegetable vine crops system (39.11 %). While, minimum silt content was noted in Mango + Turmeric based Horti - Tuber crops system (21.41 %). In this case also, silt content in the soils of 15 – 30 cm depth showed similar trend as that of silt content from soils of 0 - 15 cm depth. Furthermore, sand content in the soil at 0 – 15 cm depth was found to be maximum in Mango + Sorghum based Horti – Pastoral system (44.65 %) which was statistically at par with Mango + Colocasia based Horti – Tuber crops system (44.34 %). While, minimum was registered in Mango + Papaya based Horti – Mixed fruit crops system (17.08 %). Whereas at the depth of 15 – 30 cm soil, sand content showed similar trend to those of soils collected from 0 – 15 cm depth at different agroforestry systems. After analyzing all surveyed soils, soil samples collected from Valsad district were found to be clayey loam and loam in texture. Similar trends of result were earlier reported by Chhina et al (2019) and Pinho et al (2012).

Table 1. Soil texture Variations in different horticulture-based agroforestry systems in Valsad district of South Gujarat

Taluka	Texture Horticulture-based agroforestry systems	Depth of Soil (cm) Clay (%) 0 - 15	Clay (%) 15 - 30	Silt (%) 0 - 15	Silt (%) 15 - 30	Sand (%) 0 - 15	Sand (%) 15 - 30	Class
Dharampur	Mango + Sweet potato	28.44	28.46	35.67	34.47	35.89	37.07	Loam
	Mango + Sorghum	32.29	31.68	37.32	38.52	30.38	29.80	Clay loam
	Mango + Ivy gourd	29.11	30.16	39.11	39.87	31.78	29.97	Clay loam
	Mango + Okra	31.22	31.25	32.45	31.12	36.33	37.63	Clay loam
	Mango + Sponge gourd+ Cucumber	33.64	33.67	29.43	28.74	34.93	37.59	Clay loam
Kaparada	Mango + Banana + Brinjal	29.91	28.56	26.88	25.23	43.19	46.21	Clay loam
	Mango + Colocasia	27.22	28.26	28.44	29.91	44.34	41.83	Loam
	Mango + Sorghum	26.13	27.15	29.22	30.32	44.65	42.53	Loam
	Mango + Chili	29.25	30.05	29.31	28.57	41.44	41.38	Clay loam
	Mango + Rice	28.11	26.78	32.40	31.51	39.49	41.71	Loam
	Mango + Banana + Sapota	29.23	29.34	30.52	31.51	40.25	39.15	Clay loam
	Mango + Sponge Gourd + Cowpea + Cucumber	26.40	26.65	43.48	41.43	30.12	31.92	Loam
Valsad	Mango + Amorphophallus	52.33	51.43	24.54	26.23	23.13	22.34	Clay
	Mango + Papaya	54.30	54.08	28.62	25.54	17.08	20.38	Clay
	Mango + Sorghum	51.63	52.34	25.33	26.78	23.04	20.88	Clay
	Mango + Turmeric	57.52	56.78	21.41	20.48	21.07	22.74	Clay
	Mango + Okra	52.94	53.32	26.54	27.50	20.52	19.18	Clay
	Mango + Papaya + Brinjal	54.12	54.78	24.11	23.51	21.77	21.71	Clay

References

Chhina LK, Gupta RK, Kukal SS 2019. Soil structural attributes in relation to land use in Shiwaliks region of Northwest India. *J of Soil Water Conserv* **18**:(1):22-26.

Pinho RC, Miller RP, Alfaia SS 2012. Agroforestry and the Improvement of Soil Fertility: A view from Amazonia. *Appl. Environ. Soil Sci.* 1-11

5.39/T_5-175

Mapping Degraded Lands in Coastal Region of Navsari using Remote Sensing and GIS Technique

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Keywords: GIS, Sentinel-2A MSI, land use, satellite imageries

1. Introduction

Land is the most valuable resource to meet the plant human and animal needs. However, it is facing serious threats of deterioration due to unrelenting human pressure and utilization incompatible with its capacity. One of the major threats to the environment and the livelihoods of people worldwide is land degradation. In order to understand degradation, remote sensing is essential for assessment and monitoring at various spatial and temporal scales.

2. Material and methods

Due of its proximity to the ocean, the Navsari district's Jalalpore and Gandevi coastline blocks have been chosen. Sentinel-2 satellite imagery was used in the current analysis to map the degraded lands. The Copernicus Open Access Hub provided the pre- and post-monsoon season Sentinel-2A MSI images (processing Level-1C) for the years 2018 and 2019. These data were processed to provide Level-2A (atmospheric correction) data. Pre - and post-monsoon soil samples from 2018 and 2019 were periodically collected from 24 different sites for EC, pH, and exchangeable sodium percentage analysis. For broader landuse and land cover classification for the research period, the unsupervised isodata algorithm was used. Additionally, a weighted overlay analysis employing data on landuse, EC, pH, and ESP was used to create a map of land degradation.

3. Results and discussion

The overall size of the two blocks of Navsari district is roughly 97711 hectares, according to the results of satellite imageries study. However, 46560 hectares of coastline land totaling 50% of the combined area from both blocks were selected.

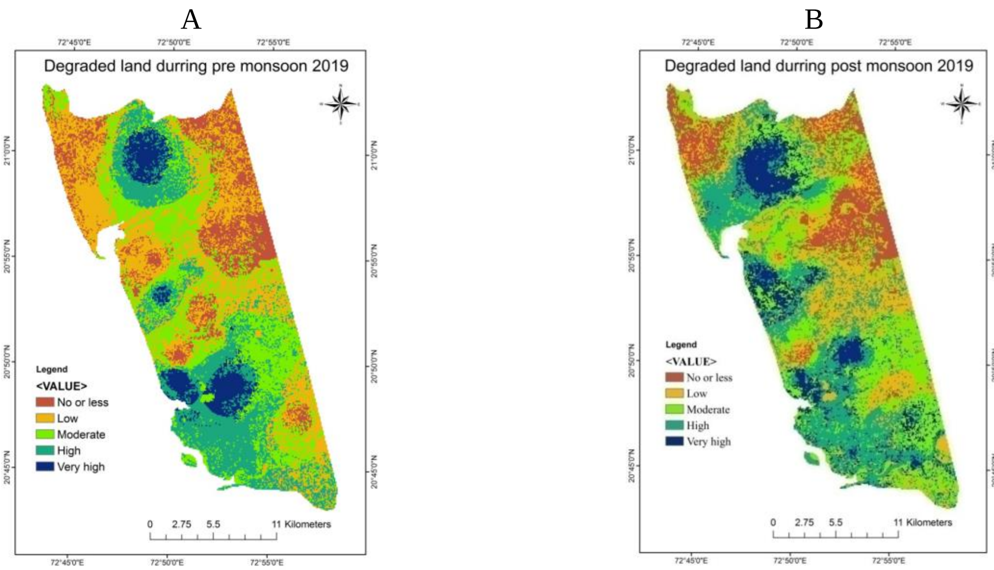

Fig. 1. Degraded land map during pre-monsoon 2019 (A) and post monsoon 2019 (B)

The largest portions are in the muddy and other swampy lands (12397 ha), followed by barren ground (11014.8 ha), then trees and vegetation (7368 ha), then agriculture and crops (8667.3 ha). The increase in barren land could be due to increase in salinity and alkalinity levels along sea coast (Nayak et al 2022). In contrast, pH and ESP were found to be higher in the post-monsoon period in both years, which may be related to changes in land use and relatively lower permeability (Nilam Surve et al 2015). Soil EC was observed to be greater in the pre-monsoon than the post-monsoon in both years. This analysis (figure 1 &2) revealed that over 50% of the coastal lands in the Navsari region were unusable coastal deteriorated areas (muddy, barren).

References

Nayak D, Surve Nilam and Shrivastava PK 2022. Assessing land use and land cover changes in South Gujarat. *Journal of Ecology Environment and Conservation* **28**(4): 2110-2115.

Surve Nilam, Shrivastava PK, Nayak D. and Wandre S. 2015. Physiographic characterization of micro watershed: A case study of NAU campus. *Indian Forester* **141**(9): 151-955.

5.40/T_5-176

Forest Fire: Impacts on Floral Biodiversity

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Keywords: Forest fire, biodiversity, vegetation

1. Introduction

Forest fires have many implications for biological diversity. Fire plays a crucial role in vegetation composition, biodiversity, soil erosion and the hydrological cycle. Forest fire decreased tree species richness in several stages of vegetation growth and also decreasing the diversity of soil macrofauna of tropical forest. Moreover, wildfires significantly reduced habitats of fauna.

2. Material and methods

This paper pertains to review of studies carried out in various parts of world on impacts of forest fires biodiversity. Literature was collected from library and google and compiled to know the impacts for different types of fires and different places on forest vegetation.

3. Result and discussion

Frequencies of major wild fires in the world are increasing during last ten years. Burn area ranged from 760 ha to 20.9 million hectare. Forest types varied from boreal forest to mixed evergreen forest (Mishra, 2021). Kelley and Thygesen (2022) revealed that at the end of the century, the likelihood of catastrophic wildfire events will increase by a factor of 1.31 to 1.57. Even under the lowest emissions scenario, they have noticed a significant increase in wildfire events. Area affected by fire in top 20 districts of India during 2003-2016 and revealed that the top 20 districts represented 48 per cent of the total area affected by fire and majority of them belong to the central cluster. The North-eastern cluster accounts for the maximum forest cover of (36 %) where the number of fire detections 55 per cent however, the maximum forest burnt area (56 %) was noticed in the central cluster (Sewak et al 2021). Forest fire causes imbalances in nature and endangers biodiversity by reducing faunal and floral wealth. The frequencies of major wild fires in the world are increasing during last ten years and a significant increase was observed in wildfire events. Tree species like *Shorea robusta*, *Pinus roxburghii* and *Tectona grandis* are least affected by fire incidence as compare to other tree species like *Butea monosperma* and *Diospyros melanoxylon*. However, maximum impacts of fire were found on trees in which have smaller stem size. Forest fire decreased tree species richness in several stages of vegetation growth and also decreasing the diversity of soil macro fauna of tropical forest. Moreover, wildfires significantly reduced habitats of fauna (Mendelsohn et al 2008; Saravanan et al 2014).

Reference

Mishra SP 2021. Pyro geography and Indian quest during Anthropocene to COVID-19. *Int. J. of Environment and Climate Change* **11**(7): 133-149.

Kelley DL and Thygesen 2022. Spreading like wildfire the rising threat of extraordinary landscape fires. *A UNEP Rapid Response Assessment*. Nairobi.

Sewak R, Vashisth M and Gupta L 2021. Forest Fires in India. *J. of University of Shanghai for Sci. and Tech*, **23**(7): 247-259.

Mendelsohn MB, Brehme CS, Rochester CJ, Stokes DC, Hathaway SA and Fisher RN 2008. Responses in bird communities to wildland fires in southern California. *Fire Ecology* **4**(2): 63.

Saravanan V, Santhi R, Kumar P, Balasubramanian A and Damodaran A 2014. Influence of forest fire on floral diversity of the degraded shola forest ecosystem. *Int Res J Bio Sci* **3**(1): 49-56.

5.41/T_5-183

Divergence of *Pseudomonas fluorescens* Bacterial Density in Diverse Forest and Plantation Ecosystem Soils: Influence of Soil Parameters on Bacterial Density

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Keywords: Bacterial density, forest ecosystem, electrical conductivity, soil moisture

1. Introduction

Pseudomonas fluorescens is a common, multi-flagellated, Gram-negative, rod-shaped bacteria, which are anti-phytopathogenic and plant growth promoting rhizo-bacteria that stimulates plant development by producing a variety of plant growth hormones, P-solubilizing activity, and nitrogen fixation. Soil is significant life support system which provide anchorage for roots, hold moisture and nutrients. Healthy soils are crucial for healthy development of plant.

2. Materials and methods

Soil sample was collected from 10 forest ecosystem. Sampling was carried out as method proposed by Parewa et al (2016) and plot descriptions were recorded. Readymade dehydrated Kings B media was used. All the glassware and media needed for plating was sterilized with autoclave in 121^0C at 15 psi pressure. Culture plates were prepared using spread plate technique for bacterial culture. Culture plates were incubated in biochemical oxygen demand incubator for 48-72 hours at 28 ±2ºC. Colonies numerated through digital colony counter *via* morphological characterization which involves Gram's Staining. Soil p^H and EC determined using p^H meter, EC Bridge. Soil moisture content determined using Thermo-gravimetric method.

3. Results and discussion

The results of variation of *Pseudomonas fluorescence* bacterial density in different forest ecosystems with soil p^H, electrical conductivity and moisture percentage was depicted in table 1. It reveals that highest abundance of *Pseudomonas fluorescens* observed in Myristica swamp followed by Evergreen, Semi-evergreen encompassing density as 99,311.60, 86,496.79, and 81,846.48respectivelyand Log CFU/gm values as 4.997, 4.937 are 4.913respectively. Highest soil p^H (6.497) recorded in Mangroves and lowest was in Myristica Swamp (5.030).

Table 1. Variation of *Pseudomonas fluorescence* bacterial density in different forest ecosystems with soil p^H, electrical conductivity and moisture percentage.

Ecosystem	Champion and Seth classification (1968)	CFU/ gm	Log (CFU/ gm)	p^H	EC (dS/m)	Moisture percentage (%)
Evergreen	Southern Tropical Wet Evergreen Forest (1A)	86,496.79	4.937	5.113	0.145	52.883
Semi-evergreen	Southern Tropical Semi-Evergreen Forest (2A)	81,846.48	4.913	5.267	0.127	48.937
Moist deciduous	Southern Tropical Moist Deciduous Forest (3A)	40,086.67	4.603	5.757	0.070	42.657
Dry deciduous	Southern Tropical Dry Deciduous Forest (5A)	38,018.94	4.580	5.957	0.065	32.107
Myristica swamp	Myristica Swamp Forest (4C/FS_1)	99,311.60	4.997	5.030	0.128	66.320
Mangroves	Mangrove Forest (4C/TS_2)	11,142.95	4.047	6.497	0.195	142.673

Scrub	Southern Tropical thorn Forest (6A)	8,570.38	3.933	5.513	0.044	15.223
Teak plantation	Teak plantation	5,128.61	3.710	5.927	0.044	25.770
Acacia plantation	Acacia plantation	10,889.30	4.037	5.483	0.108	24.157
Eucalyptus plantation	Eucalyptus plantation	31,117.16	4.493	5.110	0.127	29.040
C.D.		37,629.11	0.451	0.712	0.076	17.355
SE(m)		12,666.45	0.152	0.24	0.026	5.842
C.V.		50.17	5.94	7.463	42.053	21.090

Highest Electrical conductivity was also recorded in Mangroves (0.195dSm^{-1}) and the lowest was in Scrub Forest (0.044dSm^{-1}) and Teak plantation (0.044dSm^{-1}). Maximum soil moisture percentage was observed in Mangroves followed by Myristica swamp, Evergreen forests and values recorded are142.673, 66.320 and 52. 883 percent respectively. Study showed that in sequential sere ecosystem *i.e.,* Dry deciduous, Moist deciduous, Semi-evergreen and Evergreen Forest. Bacterial density inversely related with pH and directly related with Electrical conductivity and Soil moisture percentage. The presence of microorganisms in soil depends on their chemical composition, moisture, p^H, Electrical conductivity and structure. Many factors *viz.,* chemicals secretion, secondary metabolites (litter), decomposition, insolation *etc.,* influenced on bacterial density (Furtak and Gajda 2018).

References

Furtak K and Gajda AM 2018. Activity and variety of soil microorganisms depending on the diversity of the soil tillage system. *Sustainability of agroecosystems***:** 45.

Parewa HP Jain LK Mahajan G and Bhimawat BS 2016. Soil Health Card: A Boon for the Indian Farmers. *Indian Journal of Plant and Soil* **3**(2):77-81.

5.42/T_5-184

Surface Water Mapping using Google Earth Engine (GEE) for South Gujarat Forest

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Keywords: Remote sensing, Surface water mapping, NDWI, Forest hydrology, GEE

1. Introduction

Water bodies need to be analysed and monitored consistently for efficient management of the forest's water resources. Precise spatial and temporal information of surface water in forest area gives vital data for forest hydrology, planning of water conservation structures, providing crucial knowledge for wild animal watering and assisting in the monitoring of effects on delicate water-related ecosystems. In spite of having high rainfall than other distinct of Gujarat, The Dang experience low availability of water particularly in dry season. Present study aims to study the availability of water during dry season.

2. Material and methods

The study was conducted in the Dang district of heavy rainfall zone in the southern part of the state of Gujarat in western India. Multidate sentinel 2 satellite data was used for assessing spatial and temporal change in surface water body. QGIS software and Google earth engine were used for NDWI index generation, classification and extract water bodies.

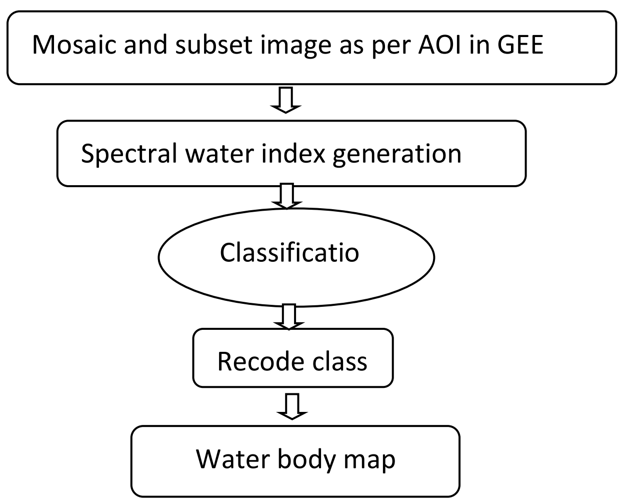

Fig. 1. Methodology flow chart

3. Results and discussion

The extent of water body for Dang district during post monsoon season for year 2017-2022 was estimated using multidate NDWI index. The extent of surface water bodies is gives in table 1. The higher surface water area was observed during January month. The lowest value of surface water was observed in may month. The result shows that the reduction in water surface area during dry season. Rapid spatial and temporal surface-water assessment using remote sensing techniques opens up a lot of possibilities for managing, monitoring, and planning of forest water resources.

Table 1. Surface water area of the Dang District

Year	Surface water area (km^2)				
	January	February	March	April	May
2017	9.50	7.20	4.00	2.11	0.42
2018	10.04	7.11	4.81	2.06	0.36
2019	8.05	5.19	3.11	2.11	0.49
2020	10.05	7.80	4.70	3.09	1.85
2021	10.22	7.80	4.63	2.34	1.17
2022	9.73	8.04	5.62	2.82	0.08

References

Mcfeeters, SK 1996. The use of the normalized difference water index (NDWI) in the delineation of open water features. *International Journal of Remote Sensing* **17**: 1425–1432.

Sreekanth PD, Krishnan P, Rao NH, Soam SK and Srinivasarao C. 2021. Mapping surface-water area using time series landsat imagery on Google Earth Engine: a case study of Telangana, India. *Current Science* 120(9).

5.43/T5-189

Air Pollution Tolerance Index (APTI) of Selected Trees at Navsari Agricultural University Campus

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Keywords: Air Pollution Tolerance Index, tree, sensitive species

1. Introduction

The assessment of air pollution tolerance index (APTI) of fifteen selected plant species commonly found in Navsari agricultural university campus, Navsari, Gujarat, India was carried out in May-2022. APTI value is used to categorized plant as sensitive and tolerant. The present study was conducted to evaluate the tolerance of selected trees of Navsari Agricultural University (NAU) campus by calculating Air Pollution Tolerance Index (APTI).

2. Material and methods

Fifteen tree species, namely, *Tectona grandis, Saraka ashoka, Acacia mangium, Terminalia arjuna, Azadirechta indica, Eucalyptus* spp., *Ceiba pentandra, bamboo* spp., *Alstonia schloris, Gmelina arboria, Kigelia pinnata, Ficus religiosa, Syzygium cumini, Lagerstroemia speciosa, Haplophragma adenophyllum* which are found in NAU campus were selected for present study. Fully matured leaves were collected from the selected tree species in morning were brought to the laboratory and were analysed for four biochemical parameters namely, Leaf Relative Water Content (RWC), Ascorbic Acid content (AA), Total leaf Chlorophyll (TCh) and leaf extract pH; APTI was calculated using the formula APTI = [A(T+P) + R]/10 (Manjunath and Reddy 2017 and Sahu et al 2020).

3. Results and discussion

APTI values of the selected trees were found as follows: *A. Indica* >*S. cumini*> *C. pentandra*> *Eucalyptus* spp.>*Bamboo* spp.> *Acacia mangium*> *F. religiosa*>*K. pinnata*>*A. schloris*>*H. adenophyllum*>*S. ashoka*>*T. arjuna*>*L. speciosa* >*T. grandis* > *G. arboria*. The highest APTI was exhibited by *A. Indica* and the lowest by *G. arboria*. *A. Indica* was found to be a tolerant species and *G. arboria* was reported as sensitive species to the pollution. However, the present study was carried out only for one season and only at one location; hence, it is recommended to do the seasonal and multilocation study to get detail information about the air pollution tolerance of the selected species.

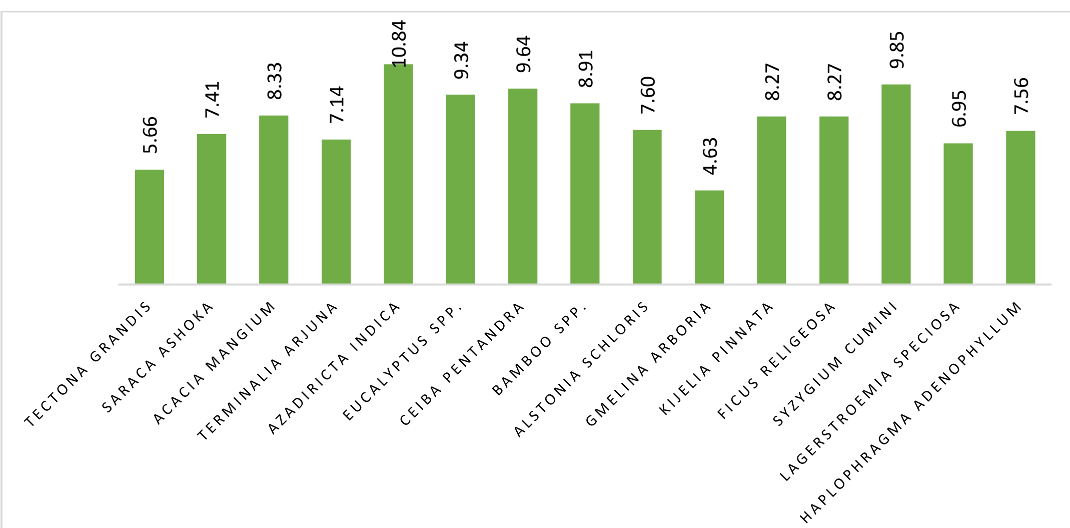

Fig. Air Pollution Tolerance Index of the selected trees of NAU campus

References

Manjunath BT and Reddy J 2017. Assessment for Variation of Air Pollution Tolerance Index of Selected Plants in Bengaluru Urban. *International Journal of Life Sciences Scientific Research* **3**(6):1522-1526.

Sahu C, Sradhanjali B and Sahu SK 2020. Air pollution tolerance index (APTI) and expected performance index (EPI) of trees in Sambalpur town of India. *SN Applied Sciences* **2**:1327.

5.44/T_5-190

Biodiversity of Insect Pests in Sal (*Shorea robusta*)

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Keywords: Biodiversity, insect-pests, lepidoptera, nursery pests

1. Introduction

Sal (*Shorea robusta*), the most valuable timber species. It is distributed in over 10 million ha of forests in central and northern India. It occupies about 1, 05,790 sq. km of the total forest cover of the country This tree has a highest number of insect fauna, about 346 insects recorded on sal, about 155 species are mainly defoliators (114), seed-feeders (19) borers (18), and sap-suckers (4), which attacks on different parts causing massive damage to tree health as well as timber quality.

2. Materials and Methods

Shorea robusta is one of the most indispensable species in Nepal, both ecologically and economically. The method involves reviewing both published and unpublished research articles. Google Scholar and Research gate were the primary databases for obtaining the pieces of literature with keywords "*Shorea robusta"* The pieces of literature were reviewed multiple times and the information about *S. robusta* were gathered. This paper aims to provide updated guidance for the biodiversity of insect pests and its management strategies, compiled, arranged, and finally drafted in a present manuscript.

Results and discussion

S. robusta is reported to be attacked by 346 insect fauna that target roots, seeds, seedlings, full-grown timbers, storage, foliage, and other parts of the plant. Large scale nursery of sal is not common. However, in artificial regeneration areas insects feeding on the sal seedlings are grouped into root feeders and defoliators. There are 112 defoliators recorded on sal, out of which 92 species belong to order Lepidoptera, 15 species belong to order Coleoptera, 4 species belong to Thysanoptera and only one species belongs to the order Orthoptera.

Table 1. Insects recorded on Sal

Order	Number of insect species	Percentage of insect species
Coleoptera	191	55.20
Lepidoptera	126	36.42
Thysanoptera	10	2.89
Isoptera	9	2.60
Hemiptera	4	1.16
Orthoptera	4	1.16
Ephemeroptera	1	0.29
Hymenoptera	1	0.29
Total		346

5.45/T_5-202

A bird's eye view on influence of forest management practices on soil carbon stock and greenhouse gas emissions

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Keywords: Soil carbon, greenhouse gas emissions, forest management

1. Introduction

Forest soil carbon (C) is a significant component of the global C cycle as >40% of the total organic C in terrestrial ecosystems is stored in forest soils. By altering rates of input or release of C from soils, forest management activities can influence soil C stocks in forests. In this review, we synthesized literature on forest management practices that can contribute to climate change mitigation by affecting soil C stocks and greenhouse gas fluxes (GHG) in forest ecosystems.

2. Materials and Methods

For this review we used major databases like google scholar and web of science to search for published peer reviewed articles and meta-analysis on soil carbon stock and greenhouse gas emissions as affected by forest management practices. In this review we considered forest management activities *viz*., tree species selection, soil preparation, fertilization, harvesting practices and fire management.

3. Results and discussion

Specific Forest management strategies can improve carbon sequestration capacity and carbon stocks in the soil and reduces the emissions. Harvesting practices particularly whole tree and stump harvesting results in a reduction in soil carbon stock compared to stem only cutting. Nitrogen fertilization increases the soil C stock and N_2O emissions while decreasing the CO_2 and CH_4 emissions. Soil carbon stocks also differ with different tree species. Carbon losses are greater in broadleaf forests than in coniferous or mixed forests. Management of tree stand density and thinning have small effects on forest soil C stocks. Soil disturbance from site preparation led to decrease in soil C stocks and increased emissions particularly in organic soils. Fire management practices such as prescribed burning reduce soil C stocks substantially but intense reduction occurs with wildfires. For each practice, we identified knowledge gaps in assessing the effects on management on forest soils. Overall, it provides forest managers with an overview of promising practices and strategies that can be implemented to mitigate climate change, by increasing forest C sequestration capacity.

Table 1. Effect of forest management practices on the soil carbon stock and greenhouse gas emissions and summary of identified knowledge gaps

Management practice	Soil carbon stock	Carbon dioxide (CO_2) emissions	Methane (CH_4) emissions	Nitrous oxide (N_2O) emissions	Knowledge gaps in assessing influence of forest management practices on forest soils
Tree species selection	Increase with coniferous species	-	-	-	✓ Limited data on long term monitoring of mixed species forests ✓ Effects of tree species on soil stock (litterfall, decomposability of organic matter)
Site preparation	Decrease - No effect	Increased emissions	No effect	No effect	✓ Limited information on soil hydrological changes (soil

		on organic soils No effect on mineral soils			temperature and moisture) after mechanical site preparation ✓ Different site preparation methods and their disturbance effects
Nitrogen fertilization	Increase	Decrease	Decrease	Increase	Changes in soil microbes, tree growth and amount and quality of litterfall by fertilization
Stand thinning and harvesting	Decrease	Increase	CH_4 Uptake Decrease	Increase	Inaccurate estimation of litter input to soil and lack of data on characteristics of initial stand before thinning and harvesting
Fire Management	No effect-decrease	Decrease	Decrease	-	✓ Long term data on GHG emissions during post fire management ✓ Impact of forest fires on soil physico-chemical and biological properties

References

Nave LE, Vance ED, Swanston CW and Curtis PS 2010. Harvest impacts on soil carbon storage in temperate forests. *Forest Ecology and Management* **259**: 857-866.

Chan ASK, Steudler PA, Bowden RD, Gulledge J and Cavanaugh CM 2005. Consequences of nitrogen fertilization on soil methane consumption in a productive temperate deciduous forest. *Biology and Fertility of Soils* **41**: 182-189.

6.1/T_6-8

The Effect of Biofertilizer and Inorganic Fertilizers on the Growth Parameters of Patchouli (*Pogostemon cablin* Benth.)

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Keywords: Patchouli, VAM, fertilizer, biofertilizer, inorganic fertilizer

1. Introduction

Patchouli (*Pogostemon cablin* Benth.), is one of the important aromatic crops belonging to the family Lamiaceae and is native to the Philippines. Among the various nutrients Nitrogen, Phosphorus and Potassium are the important nutrients that are frequently in short supply in the soil and their application plays a very important role in altering various growth, of the plants.

2. Material and methods

The experimental site was located at latitude 12 58' North, longitude 77 55' East, and an elevation of 243.84 m above MSL. A ten-treatment combination using two levels of each type of fertilizer, biofertilizer and inorganic fertilizers is used. Ten applications in order with varieties cv. Kelker was planted on August 1st, 2021, in plots with a spacing of 60 cm x 60 cm. Statistical analysis was carried out using Randomised Block Design (RBD).

3. Results and discussion

The maximum values of plant height, leaves per plant, number of branches, Length of branches/plants, leaf area index in both 1st and 2nd harvesting were recorded in treatment {100%GRDF+PSB (10g plant-1) +VAM (20g plant-1) +Azotobacter (10g plant-1)}. These results are in accordance with the results of Singh and Rao (2009) and Sumathi et al (2012). Based on the above discussion it is concluded that the application of {100%GRDF+PSB (10g plant-1) +VAM (20g plant-1) +Azotobacter (10g plant-1)} favoured most for higher growth of patchouli under typically tropical with hot and humid summers having heavy rainfall climate of Dapoli.

References

Singh M, Rao SG 2009. Influence of sources and doses of N and K on herbage, oil yield and nutrient uptake of patchouli [*Pogostemon cablin* (Blanco) Benth.] in semiarid tropics. *Industrial Crops and Products* **29**: 229-234.

Sumathi M, Shashekala SG, Shankaraiah N, Ravi KP and Kavitha V 2012. Effect of nitrogen and VAM levels on herbage and oil yield of patchouli (*Pogostemon patchouli* Petlle.). *International Journal of Science and Nature* **3**(3): 571-759.

6.2/T_6-26

Standardization of Macropropagation Protocol of *Toona ciliata* M. Roem under Punjab Conditions

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Keywords: *Toona ciliata,* micropropagation, rooting, coppice shoot

1. Introduction

The technique of propagation through vegetative means have been standardized for a large number of species, yet limited work on *T. ciliata* under Punjab conditions has been undertaken. In this experiment, macropropagation technique has been standardized through scientific improvement for large scale production of planting materials using low-cost conventional methods.

2. Material and methods

Planting season and conditions, type of planting material for cuttings, growing media and growth regulator for significant macropropagation of *T. ciliata* were assessed under this study. Planting season: mid-March, mid-July and mid-November; planting material: juvenile stem cuttings from one year old plants and one year old coppicing shoots from coppiced tree were used in the study. Growing media and growth regulators were: two media *viz.*, vermiculite and Soil:Sand:FYM (1:1:1) along with two auxins *viz.* IBA and NAA with 500, 1000, 1500 and 2000 ppm concentrations each along with a control were used for planting cuttings.

3. Results and discussion

Both the growing media, vermiculite (under mist chamber conditions than greenhouse conditions) gave better results for all the characters observed as compared to Soil:Sand:FYM media with similar planting conditions for both stem cuttings and coppicing shoots in mid-March.

Table 1. Effect of planting conditions, growing media and growth regulator on sprouting, rooting, survival, root length, collar diameter and days to sprout of stem cuttings of *Toona ciliate* (Where, Media 1: Vermiculite; Media 2: Soil:Sand:FYM (1:1:1); M: Mist chamber conditions; G: Greenhouse conditions)

Treatments	Sprouting per cent				Rooting per cent				Survival per cent			
	Media 1		Media 2		Media 1		Media 2		Media 1		Media 2	
	M	G	M	G	M	G	M	G	M	G	M	G
Control	58.33	51.67	30.00	33.33	55.00	45.00	43.33	30.00	53.33	36.67	38.33	18.33
IBA 500 ppm	71.67	56.67	48.33	43.33	66.67	48.33	51.67	38.33	63.33	43.33	48.33	36.67
IBA 1000 ppm	55.00	45.00	25.00	35.00	51.67	38.33	30.00	35.00	50.00	30.00	28.33	25.00
IBA 1500 ppm	51.67	33.33	26.67	23.33	45.00	31.67	30.00	23.33	41.67	28.33	28.33	11.67
IBA 2000 ppm	50.00	21.67	23.33	23.33	41.67	18.33	21.67	21.67	38.33	18.33	18.33	8.33
NAA 500 ppm	55.00	20.00	36.67	20.00	48.33	16.67	31.67	11.67	43.33	8.33	28.33	5.00
NAA 1000 ppm	31.67	18.33	28.33	11.67	25.00	16.67	25.00	8.33	21.67	3.33	23.33	0.00
NAA 1500 ppm	26.67	15.00	18.33	10.00	21.67	8.33	13.33	0.00	16.67	0.00	10.00	0.00
NAA 2000 ppm	28.33	11.67	10.00	3.33	23.33	1.67	6.67	0.00	18.33	0.00	6.67	0.00

SEM	4.99	1.63	1.39	1.27	1.69	1.58	1.43	1.27	1.58	1.26	1.63	0.94
CD (0.5%)	14.96	4.88	4.16	3.82	5.07	4.75	4.29	3.82	4.75	3.77	4.89	2.82
CV%	18.95	9.11	8.78	9.68	6.78	10.89	8.80	11.67	7.12	11.65	11.06	13.77

Table 1. Conted…

Treatments	Root length				Collar diameter				Days taken to sprout			
	Media 1		Media 2		Media 1		Media 2		Media 1		Media 2	
	M	G	M	G	M	G	M	G	M	G	M	G
Control	10.03	7.49	6.42	4.67	23.00	21.00	23.00	17.00	10.00	12.00	12.00	14.00
IBA 500 ppm	16.83	10.93	9.40	6.31	27.00	26.00	30.00	24.00	9.00	10.00	12.00	13.00
IBA 1000 ppm	10.00	8.48	3.96	3.74	13.00	17.00	23.00	22.00	10.00	12.00	12.00	14.00
IBA 1500 ppm	11.22	6.25	3.42	3.42	20.00	18.00	20.00	18.00	10.00	12.00	13.00	15.00
IBA 2000 ppm	7.77	4.13	6.75	2.73	23.00	15.00	17.00	16.00	10.00	13.00	12.00	15.00
NAA 500 ppm	12.15	3.74	7.71	2.10	10.00	16.00	33.00	17.00	9.00	13.00	13.00	15.00
NAA 1000 ppm	9.75	3.22	3.86	0.00	27.00	14.00	23.00	0.00	10.00	13.00	13.00	16.00
NAA 1500 ppm	14.33	0.00	5.67	0.00	17.00	0.00	20.00	0.00	10.00	13.00	14.00	16.00
NAA 2000 ppm	10.79	0.00	3.10	0.00	20.00	0.00	17.00	0.00	10.00	14.00	15.00	16.00
SEM	0.16	0.07	0.09	0.04	0.38	0.22	0.28	0.21	0.14	0.23	0.19	1.00
CD (0.5%)	0.47	0.22	0.27	0.12	1.14	0.67	0.83	0.63	0.41	0.68	0.57	3.01
CV%	2.35	2.57	2.83	2.69	3.31	2.76	2.09	2.88	2.43	3.17	2.56	24.02

The overall maximum sprouting percentage of 71.67% from stem cuttings and 23.33 % from coppicing shoots was observed in cuttings treated with IBA 500 ppm. Similarly, maximum rooting and survival percentage of 66.67% and 25.00% was observed from stem cuttings whereas it was 11.67% and 11.67% for cuttings from coppicing shoots. Maximum root length and collar diameter of 16.83 cm and 27 mm was observed from stem cuttings whereas it was 14.23 cm and 23 mm for cuttings from coppicing shoots.

Reference

Kaur A, Singh A and Monga R 2019. Vegetative propagation of an endangered tree Species *Tecomella undulata*. *Indian Journal of Ecology* **46**(1): 208-210.

6.3/T_6-40

Growth Performance of Two-year-old *Artocarpus heterophyllus* Lam under Variable Stand Density Regimes

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Keywords: *Artocarpus heterophyllus*, jack fruit, growth, wood, planting density

1. Introduction

Artocarpus heterophyllus Lam. (Jack tree) is an excellent multipurpose tree species for the humid tropics, especially for Kerala. Jack is an integral component in the traditional home gardens and farm boundaries of Kerala primarily aiming at jackfruit, the unique delicacy of Kerala. Despite the good quality and high demand for jack wood, species is seldom cultivated in Kerala exclusively for timber purposes. Standardization of optimal planting density assumes the most important management strategy for quality timber production. The present study is an attempt in this line.

2. Material and methods

A field trial for the assessment of the growth performance of jack at variable planting densities, was established at Suhasini hills, Kerala Agricultural University campus, Thrissur, Kerala in August 2020, in a randomized block design with four replications. The plant spacing treatments for the study were 3×3 m, 3×4 m, and 3×5 m which were accommodated in plots of variable sizes such that each plot occupied 16 jack trees counting 192 trees in total. After the first year of field establishment, growth observations were recorded from September 2021 onwards on a quarterly basis.

3. Results and discussion

Variable planting spacing showed significant changes in height, the number of branches, crown height, crown length, and crown width, for Jack plants at two years of stand age. Higher values for tree height, collar diameter, crown length, and the number of branches were recorded for closely spaced plots (3 x 3 m) while wider spacing (3×5 m) showed higher values for crown height, crown width, and diameter at breast height (Table 1). However, the variations were non-significant for collar diameter and DBH. Early results indicate that a competitive response in growth was initiated among the jack woodlots managed at variable spacing. Fast growing habit of jack under managed conditions was obvious in the study with a height increment attaining 1.5 m yr-1 (Acedo 1992). Furthermore, initial trends indicate that closer spacing promotes straight and taller trunks (Kunhamu 2011).

Table 1. Changes in growth attributes of two-year-old Artocarpus heterophyllus managed at variable planting spacing at Thrissur, Kerala

Planting spacing (m)	Growth attributes						
	Height (m)	Collar diameter (cm)	Branch number	Crown height (m)	Crown length (m)	Crown width (m)	DBH (cm)
3x3	3.55^a	6.02	20.75^a	0.90^b	2.66^a	1.54^a	5.15
3x4	3.10^b	5.21	16.42^b	1.00^a	2.10^b	1.28^b	4.42
3x5	3.18^b	5.83	17.98^b	1.02^a	2.16^b	1.58^a	5.17
p-value	<0.003	NS	<0.000	<0.03	<0.0003	<0.032	NS

References:

Acedo AL 1992. Multipurpose Tree Species Network Series: Jackfruit biology, production, use, and Philippine research. Forestry/Fuelwood Research and Development Project.

Kunhamu TK 2011. Jack and Agroforestry. The Jackfruit, pp. 177–189.

6.4/T_6-46

Early Seedling Growth of (*Terminalia chebula* Retz.) as Influenced by Different Pre-sowing Treatments

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Keywords: *Terminalia chebula*, pre-sowing treatments, germination

1. Introduction

T. chebula "The king of medicines" has been potentially recognized in Ayurveda. The medicinal value has raised the demand for its fruit with the shifting trends from allopathic to ayurvedic medicines. But the lower germination capacity (hard endocarp, poor kernel development, and seed dormancy) isa major deterrent in nursery operations and plantation development. To overcome these constraints, pre-sowing treatments are one of the most effective ways to boost the germination and seedling vigor of pretreated seeds.

Table 1. Effect of different pre-sowing treatments on various growth parameters of *T. chebula*

Treatments	Growth parameters							
	Plant height (cm)	Root length (cm)	Root:Shoot (cm)	Shoot diameter (cm)	Root diameter (cm)	Shoot biomass(g)	Root biomass (g)	No. of leaves per seedling
T_1– Control	11.2	5.8	0.52	1.2	2.8	0.58	0.15	4.28
T_2- Soaked in cold water for 24 hours	15.72	10.2	0.65	1.4	3.56	0.73	0.48	6.62
T_3 – Soaked in cold water for 48 hours	15.94	9.76	0.61	1.46	3.8	0.82	0.56	6.68
T_4 – Soaked in cold water for 72 hours	18.72	12.4	0.66	1.68	4.36	1.07	0.74	6.98
T_5 – Dipped in 50% Sulphuric acid 20 minutes	19.8	13.6	0.69	1.82	4.94	1.28	0.92	7.32
T_6 – Dipped in 50% Sulphuric acid 25 minutes	18.92	13.14	0.69	1.72	4.4	1.16	0.88	7.24
T_7 – Dipped in 50% Sulphuric acid 30 minutes	16.4	10.6	0.65	1.52	3.72	0.87	0.64	6.74
T_8 – Immersed in cow dung slurry for 15 days	15.6	9.88	0.63	1.4	3.4	0.68	0.52	6.54
T_9 – Immersed in cow dung slurry for 30 days	17.86	11.52	0.65	1.66	3.92	0.98	0.68	6.82
T_{10} – Immersed in cow dung slurry for 45 days	18.82	12.92	0.69	1.64	4.12	1.13	0.78	7.14
T_{11} - Mechanical Breaking of Seed coat	21.6	15.4	0.71	1.98	5.2	1.34	0.98	7.86
F test (0.5% level)	S	S	S	S	S	S	S	S

2. Material and methods

The experiment was conducted at the Department of Forestry, IGKV, Raipur in 2021. The study was carried out in a completely randomized design with eleven treatments in three replications. Under each treatment, 75 seeds were treated and then sown in polybags filled with soil, cow dung, and a vermicompost mixture. Data pertaining to various growth parameters were observed at regular intervals and the average was worked out over ninety days.

3. Results and discussion

Among the various treatments, the seedling raised through mechanical treatment recorded the highest plant height, number of leaves per seedling, root length, shoot and root diameter, root:shoot ratio, shoot and root biomass, followed by sulphuric acid treatment. However, each pre-sowing treatment outperformed the control in terms of seedling growth. Mechanical treatment was also reported for promoting earlier seedling emergence with quality seedling production at the lowest cost, time and labour (Shil and Prajapati 2021). The pre-sowing treatments of *T. chebula* proved to be better than the control/traditional method of sowing which usually results in germination failures. Therefore, mechanical and sulphuric acid treatments can aid in overcoming germination problems in nursery general practices and could be employed to obtain the highest quality seedlings in the short term.

References

Shil S and Prajapati RK 2021. Effect of pre-sowing treatments on seed germination of Harad (*Terminalia chebula* Retz.) in the nursery condition. *The Pharma Innovation Journal* **10**(10): 2344-2346.

6.5/T_6-48

Natural Regeneration Status of *Rhododendron campanulatum* D. Don in Western Himalayas

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Keywords: *Rhododendron campanulatum*, natural regeneration, stocking index

1. Introduction

The genus *Rhododendron* was first described by Carl Linnaeus in 1737 in Genera Plantarum. *Rhododendron campanulatum* D. Don also known as the pink Rhododendron is an endangered species of the Himalaya. It is distributed in temperate and alpine regions of northern India from Kashmir to Nagaland at 2400-5200 m elevations. The population density of the growth stages governs the population structure and status of regeneration of any forest community (Good & Good 1972).

2. Material and methods

The present study was carried out in Dodrakwar and Khashdhar Range of Rohru Forest Division of Himachal Pradesh situated between 31° 12' 36" N to 31° 14' 24" N latitude and 78° 01' 27" E to 77° 59' 44" E longitude. To study the regeneration status *R. campanulatum*, 5 sub-quadrates of 5 m × 5 m within each quadrate of size 31.62 × 31.62 m were laid out.

3. Results and discussion

From Table 1 it is inferred that the establishment index (0.97), stocking index (0.80), establishment stocking per cent (46.08) and regeneration per cent (52.78) was found to be maximum at elevation E_2 (3200-3400 m) on northern aspect in Khashdhar range.

Table 1. Regeneration study of *R. campanulatum* in Rohru Forest Division of Himachal Pradesh, India

Forest Range	Elevation	RN (ha^{-1})		UN (ha^{-1})		EN (ha^{-1})	
	(m)	NA	SA	NA	SA	NA	SA
Dodra Kwar	E_1	1111.11	555.55	555.55	277.77	833.33	555.55
	E_2	1111.11	833.33	555.55	555.55	833.33	555.55
	E_3	277.78	0.00	555.55	555.55	833.33	555.55
Khashdhar	E_1	1388.88	555.55	555.55	1111.11	833.33	277.77
	E_2	1944.44	1388.88	833.33	1111.11	1111.11	277.77
	E_3	277.78	277.78	555.55	1388.89	833.33	555.55

Table 1 continued

Forest Range	Elevation	I_1		I_2		ES		RS	
	(m)	NA	SA	NA	SA	NA	SA	NA	SA
Dodra Kwar	E_1	0.54	0.66	0.64	0.44	36.53	24.83	38.89	25.00
	E_2	0.76	0.66	0.66	0.72	37.50	27.36	38.89	27.78
	E_3	0.82	0.88	0.39	0.36	37.50	25.08	38.89	27.78
Khashdhar	E_1	0.66	0.40	0.33	0.28	38.33	13.78	38.89	21.00
	E_2	0.97	0.69	0.80	0.58	46.08	13.89	52.78	22.22
	E_3	0.96	0.92	0.39	0.36	38.89	31.96	38.89	36.11

RN=Recruits number; UN=Unestablished number; EN=Established number; I_1=Establishment Index; I_2=Stocking index; ES=Establishment stocking; RS=Regeneration success; E1=3000- 3200 m; E2=3200-3400 m; E3=Above 3400 m; E1=3000- 3200 m; E2=3200-3400 m; E3= Above 3400 m

Whereas minimum value for establishment index (0.40), stocking index (0.28), establishment stocking per cent (13.78) and regeneration per cent (21.00) was found at elevation E_1 (3000-3200 m) on southern aspect in Khashdhar range. Sharma and Raj (2004) studied the status of natural regeneration of *Juniperus macropoda* in Ladakh region and found that biotic pressure of overgrazing and lopping twigs were major factors responsible for poor natural regeneration in this species.

References

Good NF and Good RE 1972. Population dynamics of tree seedlings and saplings in a mature eastern hardwood forest. *Bulletin of the Torrey Botanical Club* **99**(4): 172-178.

Sharma BM and Raj A 2004. Status of natural regeneration of *Juniperus macropoda* Boiss. in Ladakh, the cold arid region of Western Trans Himalayas. *Indian Journal of Forestry* **27**: 237-240.

6.6/T_6-61

Pre-sowing Seed Treatments of *Tectona grandis* Linn. f.

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Keywords: *Tectona grandis,* teak, seed treatment, germination, germination index value

1. Introduction

Tectona grandis Linn. f. (Teak), (Lamiaceae family), king of timber, widely distributed in Southern and Central India, yields one of the world's most beautiful and stable wood with excellent wood qualities. Despite its great economic value and agroforestry importance, farmers are reluctant to grow Teak on farmland due to lack of quality planting material.

2. Material and methods

Seeds were collected from the superior trees from Jhalawar region during November-January months. Uniform sized vigorous seeds were treated with four different pre-sowing treatments *viz.* control (P_0), alternate wetting and drying (12hours) for 21 days (P_1), soaking in cow dung slurry (7days) (P_2), soaking in concentrated H_2SO_4 (75%) (20 minutes) (P_3). Data on various parameters *viz*. number of days taken for first germination and completing the germination, mean germination time and germination index were recorded.

3. Results and discussion

The findings of the study revealed that Teak seeds under different pre-sowing treatments ensured better germination attributes over control. Maximum germination percent (43.83%), minimum number of days taken for first germination (14 days) and complete germination (28.75 days), lower mean germination time (20.00 days) and higher germination index value (3.43) were recorded in seeds treated by alternate wetting and drying (12 hours) for 21 days (P_1) followed by seeds soaking in cow dung slurry for 7 days (P_2) germination per cent (43.83%) and germination index value (3.43)) and seeds soaking in concentrated H_2SO_4 (75%) for 20 minutes (P_3). Untreated Teak seeds germinate slowly and irregularly. Thus, pre-sowing treatments facilitate the production of quality planting material within a short span and reduce the cost of seedling establishment in agroforestry systems.

6.7/T_6-67

Effect of Different Concentration of Growth Regulator on Vegetative Propagation of *Bambusa balcooa* Bamboo

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Keywords: *Bambusa balcooa*, Rhizogenesis, Stem cutting, Plant Growth Regulator

1. Introduction

The world's forests assemblage goods and services that sustain millions of plant and animal species as well as provide industrial wood products, energy and other non-wood products. Due to the increased burden of population, the need for food and wood is increasing exceedingly in India day by day. The larger forest area has been shifted to non-forest sections for activities like agriculture, urbanization, industries, roads and other purposes. These enormous activities have caused great difficulty in meeting the increasing demand and supply for fodder, firewood and timber requirements.

2. Material and methods

The field experiment was conducted in field of AICRP on Agroforestry, College of Agriculture, Nagpur during 2021-22. The growth hormones used for stem cutting were IBA with different concentration. Solution of auxins was made and single node cutting of *Bambusa balcooa* were soaked in growth regulators (Indol-3-Butyric Acid:1500, 2000, 2500 and 3000 ppm concentrations) for 24 hours before planting at room temperature (20±1 ^{0}C). The experiment was laid out in Completely Randomized Design (CRD) replicated 5 times. In each replication, 10 cuttings were raised accordingly and data were recorded immediately after the single node cuttings emerged and subjected to statistical analysis of variance as suggested by Fisher and Yates (1963).

3. Results and discussion

The maximum number of sprouting per node cutting was observed in T1 (2.00) followed by T2 (1.40) and minimum number of sprouting per node cutting in T3 and T4 (1.20). The maximum height (cm) was recorded in T1 (48), followed by T2 (46.20). The maximum base diameter was recorded in T1 (6.40), followed by T2 (5.40), however the minimum (3.60) was recorded in T4.

Table 1. Growth characteristics of *Bambusa balcooa* under different concentration of growth regulator

Treatment	Sprouting / node cutting	Tiller height (cm)	Base diameter (mm)	No. of branches	No. of Internode	Internodal length (cm)
T1 Main culm + IBA 1500 PPM	2.00	48.00	6.40	1.60	8.20	5.20
T2 Main culm + IBA 2000 PPM	1.40	46.20	5.40	2.20	9.00	4.10
T3 Main culm + IBA 2500 PPM	1.20	41.20	5.60	1.20	8.00	4.80
T4 Main culm + IBA 3000 PPM	1.20	15.20	3.60	1.00	3.80	3.00

The maximum number of branches was observed in T2 (2.20), followed by T1 (1.60) and the minimum number of branches in T4 (1.00). The maximum number of Internode was observed in T2 (9.00) followed by T1 (8.20) and minimum in T4 (3.80). The maximum internodal length was recorded in T1 (5.20 cm) followed by T2 (4.80 cm) and minimum in T4 (3.00 cm). The maximum weight of tiller (177.00 gm) was noticed in T2 and minimum in T4 (113.00 gm). Similar hormonal effect was observed by Singh et al (2006) in other bamboo species.

References

Fisher RA and Yates Y 1963. Statistical tables for biological, agriculture and medicinal research Edinberg: Oliver and Boyd, Ltd.

Singh S, Nain NPS, Meena SL and Tripathi SP 2006. Patterns of adventitious root induction during different seasons in some bamboo species (Tropical Forest Research Institute P.O. RFRC, Jabalpur 4820211, India).

6.8/T_6-82

Effect of Different Potting Media and Plant Growth Regulators on Branch Cuttings of *Dendrocalamus asper* (Schult. and Schult. f.) Backer ex K. Heyne.

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Keywords*:* Afforestation, propagation, bamboo species, plant growth regulators.

1. Introduction

Dendrocalamus asper are commercially important bamboo species with unique features and multifarious utility. There is huge demand for these species in farming sector and afforestation programs but, the difficulty in propagation due to intermittent flowering resulting in unavailability of seeds, insufficient rhizomes and offsets. In this regard, the study was carried out to standardize nursery techniques using branch cuttings of the bamboo species in the nursery of College of Forestry, Sirsi.

2. Material and methods

In the first experiment, different potting media involving eight treatments *i.e.*, soil, sand, FYM, vermicompost, ash, neem cake manure, poultry manure and perlite at certain ratios. In the second experiment, effect of different plant growth regulators (IBA- 1000, 1500, 2000, 2500, 3000, 3500 and 10 ppm coumarin) on branch cuttings of the bamboo. The cuttings were treated and planted horizontally in polybags. The data was statistically analyzed with Opstat software using factorial randomized block design.

3. Results and discussion

The results indicated that treatment of vermicompost potting media at 2: 1: 1 ratio recorded maximum plant growth of *D. asper* planting stocks with maximum shoot length (90.57 cm), root length (40.22 cm), number of roots (20.21), survival per cent (83.33 %), fresh weight of the planting stock (94.56 g) and dry weight (24.74 g) while soil (control) recorded least. However, the plant growth parameters recorded were also higher with the potting media containing poultry manure. It was found that organic substances in potting media helps in the growth of the planting stocks as compared non-nutrient potting media.

Table 1. Effect of different potting media on growth of the *D. asper* planting stocks

Treatments	Shoot length (cm)	Root length (cm)	Total fresh weight (g)	Total dry weight (g)	Survival (%)
T_1	75.47	20.23	59.80	12.66	33.33 (35.20)
T_2	79.27	22.50	66.23	13.16	46.67 (43.06)
T_3	85.00	33.70	75.90	16.57	63.33 (52.75)
T_4	90.57	40.22	94.56	24.74	83.33 (61.20)
T_5	82.46	32.24	70.76	13.47	50.00 (44.98)
T_6	90.76	39.72	91.82	23.77	83.33 (66.12)
T_7	79.99	30.77	72.96	15.69	66.67 (55.05)
T_8	80.34	31.30	78.90	17.46	70.00 (56.77)
SEm$\pm$	0.54	0.13	0.06	0.05	2.83
CD @ 5%	1.63	0.39	0.17	0.14	8.56

T_1- Control (Soil alone), T_2 - Soil + Sand, T_3 - Soil + Sand + FYM (2: 1: 1), T_4 - Soil + Sand + Vermicompost (2: 1: 1), T_5 - Soil + Sand + FYM + Ash (2: 1: 0.5: 0.5), T_6 - Soil + Sand + FYM + Poultry manure (2: 1: 0.5: 0.5), T_7 - Soil + Sand + FYM + Neem cake (2: 1: 0.5: 0.5), T_8 - Soil + Sand + FYM + Perlite (2: 1: 0.5: 0.5); Values in the parenthesis represent angular transformation

Table 2. Effect of different plant growth regulators on growth of the *D. asper* planting stocks

Treatments	Shoot length (cm)	Root length (cm)	Total fresh weight (g)	Total dry weight (g)	Survival (%)
T_1	50.91	19.59	30.35	8.50	60.23 (50.88)
T_2	54.76	23.02	34.90	9.77	61.47 (51.61)
T_3	58.09	25.62	39.67	11.11	65.39 (53.95)
T_4	58.26	26.83	46.69	13.07	70.90 (57.33)
T_5	61.86	31.15	54.25	15.19	75.34 (60.20)
T_6	63.53	35.26	70.95	19.86	84.42 (66.73)
T_7	66.78	36.85	74.78	20.94	85.81 (67.90)
SEm$\pm$	1.16	0.38	0.50	0.14	0.46
CD @ 5%	3.54	1.16	1.53	0.43	1.43

T_1 - IBA (indole-3-butyric acid) 1000 ppm, T_2 - IBA 1500 ppm, T_3 - IBA 2000 ppm, T_4 - IBA 2500 ppm, T_5 - IBA 3000 ppm, T_6 - IBA 3500 ppm, T_7 - 10 ppm coumarin); (Values in the parenthesis represent angular transformation

It indicated that 10 ppm coumarin enhanced the growth of *D. asper* planting stocks with highest shoot length (85.08 cm), survival per cent (90 %), root length (46.22 cm), number of roots (23.42), fresh weight (74.78 g), and dry weight (20.94 g) by the application of 10 ppm coumarin and least in 1000 ppm IBA treatment. These findings suggested that use of vermicompost in potting media at 2: 1: 1 ratio and 10 ppm coumarin for branch cuttings is the best way to obtain healthy planting stocks of *D. asper*. The treatment of 3500 ppm IBA also showed greater growth as compared to other treatments. Considering the economical perspective coumarin treatment is considered to be better.

6.9/T_6-84

Nutrient Dynamics in Teak (*Tectona grandis* Linn. f) under Different Fertigation Regimes in Farm Conditions of Western Tamil Nadu

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Keywords: *Tectona grandis*, nutrient dynamics, fertigation, soil nutrient

1. Introduction

Teak is recognized as 'the paragon of timbers' (Masilamani and Annadurai 2003) and is one of the most priced timbers across the world predominately distributed in tropical and subtropical countries (White 1991). When the production cannot meet the supply, incorporation of silvicultural practices such as irrigation and fertilization can boost the tree growth and reduce the rotation age for the crop.

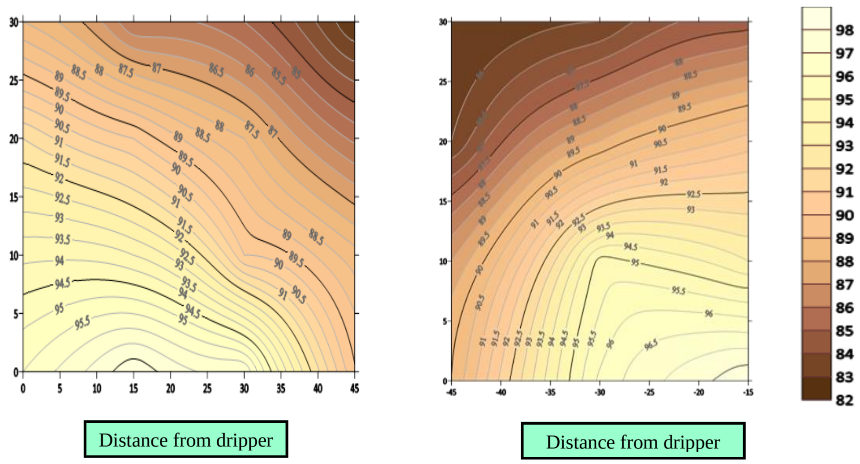
2. Material and methods

Field experiment was carried out during 2020-2021 at Pachapalayam, Coimbatore and Tamil Nadu. The experiment consists of four irrigation levels *viz*., I_1 – 50%, I_2 – 75%, I_3 – 100%, I_4 – 125% (WRt) as a main plot and three fertigation levels *viz*., F_1 – 75%, F_2 – 100%, F_3 - 125%, F_4 – 150 % (RDF) (Geetha and Balagopalan 2009) as sub plots. The irrigation was carried out through drip system once in three days based on climatological approach.

3. Results and discussion

From the analyzed data, there was an increase in the nutrient concentration (N, P, and K) with an optimum dosage of fertigation level. The maximum nitrogen content (213.5 kg ha^{-1}), phosphorus content (25.3 kg $ha^{-1)}$ and Potassium content (264.4 kg ha^{-1}) was recorded in the 125% RDF level. An extremely high amount of nutrient concentration was recorded at the proximity of the dripper point in all the fertigation levels. The conventional fertilization is characterized by the presence of maximum nutrient content far away from the teak active root zone which is not beneficial to the plants. From the results it has been clearly illustrated that drip fertigation can enhance the soil nutrient status and hence improving crop productivity.

Figure1. Nitrogen distribution (Kg ha^{-1}) in 100 % RDF under drip fertigation



References

Masilamani P and Annadurai K 2003. Seedling vigour of irrigated teak (*Tectona grandis* Linn. F.). *Indian Journal of Forestry* **26**(1): 48-52.
White KJ 1991. Teak: some aspects of research and development. RAPA publication, 17p.
Geetha T and Balagopalan M 2009. Soil fertility variations within a rotation period in teak plantations in Kerala. *Advances in Plant Science* **22**(1): 317-319.

6.10/T$_6$-94

Effect of rooting hormones on establishment and sprouting of *Commiphora wightii* in Bundelkhand Region, India

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1. Introduction

Conservation and propagation of RET plant is need of an hour. *Commiphora wightii* (Arnott) due to its overexploitation came under RET category and it propagation by using different vegetative propagation necessary. Presently our laboratory work in conservation and propagation of *C. wightii* both macropropagation and micro-propagation technique by intervention of different concentration of plant growth hormones.

2. Material and methods

In laboratory our group tried both macro and micropropagation. In macropropagation by stem cutting method applying different concentration (2000, 4000 and 6000 ppm) of different kinds of auxins like IAA, NAA. IBA, and 2-4 D. Simultaneously, nodal explant also placed in artificial media after properly sterilized condition by providing a different concentration of shoot inducing plant hormones like BAP at different concentration. Nodal explant induces propagated all the concentration of BAP, but multiplication only shown at 6 mg/ml of BAP.

Table 1. Impact of different concentrations of IAA and IBA on survival and growth parameters of *C. wightii* cuttings

Treatment	Establishment (%)	Sprouting initiation (days)	Establishment (%)	Sprouting initiation (days)
	IAA		IBA	
2000 ppm	78.00	25.00	83.10	28.00
4000 ppm	66.00	21.00	78.20	24.00
6000 ppm	73.00	23.00	74.30	26.00
control	64.00	17.00	66.30	19.00
Mean	70.3	21.8	70.6	24.00
SD	6.40	3.80	5.60	3.30
SEm (±)	3.22	1.89	2.79	1.67
C D at 5%	7.20	2.14	6.90	3.10

3. Results and discussion

The result evinced that the Influence of different concentrations of IAA, IBA, NAA, 2,4-D on growth parameters of guggul branch cuttings are presented in (Table 1). From the perusal of data, it was observed that, different concentrations of IAA, IBA, NAA, 2,4-D had a significant effect on growth parameters of guggul. Data indicated that branch cutting treated with 2000 ppm of IBA observed higher percentage of establishment (83.1%) and was at par with IBA 4000 ppm (78.2%), whereas the minimum establishment percentage (74.3%) was recorded in cuttings treated with 6000 ppm, respectively.

6.11/T_6-101

Performance and Comparative Advantage of Wood Products Trade from India

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Keywords: Growth performance, export, comparative advantage, RCA

1. Introduction

The export of total wood products from India is 0.40% of total production, though India is importing 7107 thousand m^3 wood products. This indicates the huge demand of wood products in India. The export quantity and value of different wood products from India is less than the import which showed negative balance of trade for wood products. Therefore the present investigation was carried out with the objective to study the composition, percentage share of India in the world, growth, variability and comparative advantage of export and import of different wood products from India.

2. Material and methods

Present investigation was based on secondary data collected from the official website of International Tropical Timber Organization for the period from 2001 to 2021. To study the composition and share of India in the world export and import of wood products percentage has been calculated. To find out growth and variability in quantity and value of export and import CAGR and coefficient of variation were estimated, respectively. To determine the comparative advantage RCA and RSCA worked out.

3. Results and discussion

The results of study showed that the quantity and value of export and import of total wood products raised during study period. Among the wood products exported from India the highest export quantity and value was recorded in case of plywood and veneer while the percentage share of Industrial round wood and swan wood in total wood product export was found less. The highest quantity and value of import from India found for industrial round where as it was less for plywood and veneer. The share of quantity and value of veneer import by India in world total veneer import found increased over the study period. The quantity of export and import of total wood products, Plywood and veneer from India increased significantly whereas the import of all the wood products was higher than the export during the study period. The export quantity of total wood product (47.72%) having higher variability than the import quantity of total wood products (32.81%). The higher variability in export and import quantity found in veneer, plywood and swan wood. The values of RCA and RSCA indicated that India had higher comparative advantage in export of veneer and plywood than the other wood products during the study period.

Table 5. Growth rate of export and import of wood products from India

Wood Product	Export		Import	
	Quantity	Value	Quantity	Value
Ind. Round wood	0.51	17.77***	2.64**	3.41**
Swan wood	1.01	5.14**	21.62***	23.77***
Veneer	5.10*	5.08***	30.86***	28.86***
Plywood	6.71***	8.58***	13.98***	15.68***
Total Wood Products	5.23***	8.85***	4.80***	6.67***

*, **, *** indicates the significant at 10%, 5% and 1% level of probability

References

ITTO 2022. Statistical Database. Retrieved from www.itto.int

Dalum B, Laursen K and Villumsen G 1998. Structural changes in OECD Export Specialization Pattern: De-Specialisation and Stickiness. *International Review of Applied Economics* **12(**3): 423-443.

6.12/T_6-109

Biomass Production of some Promising Fuelwood Tree Species under High-Density Plantation

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Keywords: Fuelwood tree, high density plantation, energy plantation, biomass

1. Introduction

Energy plantation is a process of producing energy. Currently fossil fuel such as oil, coal and natural gases represent the prime energy sources in the world. However, it is anticipated that these sources of energy will be depleted within the next 40-50 years. Black locust (*Robinia pseudoacacia*) is an increasingly popular tree species for the production of woody biomass for bioenergy generation with short rotation coppices. Due to its potential to produce large amounts of biomass yields even under unfavourable growth conditions, this tree species is especially suitable for marginal sites. Not much information is available with respect to growing of fuel wood plantations in Kashmir valley, therefore, in order to collect information regarding this, an experiment entitled "Biomass production of some promising fuelwood tree species under high-density plantations" has been done.

2. Materials and methods

The experiment was laid down on March 2017 at the experimental area of the Division of Silviculture and Agroforestry, with the objective to determine the biomass production of different fuelwood species in different spacings. Four species namely, 1. *Robinia pseudoacacia,* 2. *Morus alba,* 3. *Ulmus villosa* and 4. *Prunus armeniaca* were planted in three plant densities (10000, 20000 and 27777 plants ha^{-1}) with spacings 1x1 m, 1 x 0.5 m and 0.6 x 0.6 m). The experiment consisted of twelve treatment combinations comprising four tree species and three planting densities. The experimental design used was factorial randomized block design with three replications. After completion of five years, the growth and biomass data were collected during end of the dormant season. Data on biomass were collected using a stratified average tree technique. The total above ground biomass is expressed as kg tree^{-1} and tons hectare $^{-1}$. The data generated from the present investigation were put to statistical analysis.

3. Results and discussion

After completion of five growing seasons, the study revealed that the survival percentage, height and diameter were significantly influenced by tree species and plant density (Fig. 1). The data recorded have shown that survival percentage, height and diameter were decreased with the increase in plant population in all the four species. The survival (%) was maximum in *Robinia pseudoacacia* (100) followed by *Morus alba* (97.67) in density D_1 (10000 plants/ha). Minimum survival (%) was observed in *Prunus armeniaca* (85.33) in density D_3 (27777 plants/ha). The maximum height (4.30 m) and diameter (5.17 cm) were recorded in *Robinia pseudoacacia* followed by *Morus alba* (4.07m & 4.97 cm) in density D_1 (10000 plants/ha) and minimum in *Prunus armeniaca i.e.,* 2.50 m and 3.03 cm in density D_3 (27777 plants) respectively. The results are in line with the findings of Saralch *et. al.* (2005) who observed similar effects of plant spacing in *Eucalyptus tereticornis* plantation. The data on the aboveground biomass and productivity of five years old different tree species as influenced by the tree density have revealed that biomass as well as productivity per tree basis decreased as the tree population increased (Fig.2 &3). The highest aboveground biomass per tree was found to be produced under density D_1 followed by D_2 and D_3 in all four species. However, biomass as well as productivity per hectare exhibited reverse relationship i. e. density D_3 (27777 plants/ha) gave the highest biomass and productivity followed by D_2 and D_1 in all the four species. The maximum biomass (97.22 tons /ha) and productivity (19.44 tons ha^{-1} year^{-1}) were recorded in *Robinia pseudoacacia* followed by *Morus alba* (87.96 tons ha^{-1} & 17.59 tons ha^{-1} year^{-1}) in density D_3 (27777 plants/ha) and minimum in *Prunus armeniaca i.e.,* 27.07 tons ha^{-1} and 5.41 tons ha^{-1} year^{-1}) in density D_1 (10000 plants/ha) respectively. The tree species biomass production was observed as in order of *Robinia pseudoacacia* > *Morus alba* > *Ulmus villosa* > *Prunus armeniaca*. Chandra (2011) conducted the study on growth and biomass production of *Anthocephalus chinensis* in a high-density plantation (2,500 trees/ha) in Assam, India.

Thirty-six months after planting, trees reached 5.3 cm height and 9.4 mm collar diameter on average. Total biomass (dry weight) produced at age of 12, 24 and 36 months was 0.71 t/ha, 12.3 t/ha, and 35.8 t/ha respectively.

The survival percent, plant height and diameter at breast height were higher in the lowest density D_1 (10000 plants/ha) and minimum under density D_3 (27777 plants/ha) having maximum plant population in all the four species. The aboveground biomass and productivity of five years old different tree species have shown that biomass as well as productivity per tree basis decreased significantly with increase in plant density, whereas the results on hectare basis for the same parameters were exactly opposite to it. The growth parameters, biomass production and net returns of tree species were observed as in order of *Robinia pseudoacacia* > *Morus alba* > *Ulmus villosa* > *Prunus armeniaca*.

References

Chandra A 2011. Biomass production by *Anthocephalus chinensis* under high density plantation. *Forests, Trees and Livelihoods* **20(**4):301-306.

Saralch HS, Verma KS, Bharadwaj SD and Chauhan SK 2005. Productivity potential of *Eucalyptus tereticornis* Smith plantation managed under short rotation High density (SRHD) system. In: Short Rotation Forestry for Industrial and Rural Development. Eds. K S Verma, D K Khurana and Lars Christian, ISTS Nauni, Solan. India. 83-86 pp.

Fig. 1. Effect of planting density on Survival (%), Height (m) and DBH (cm) of four species namely *Morus alba* , *Robinia pseudoacacia*, *Ulmus villosa* and *Prunus armeniaca*

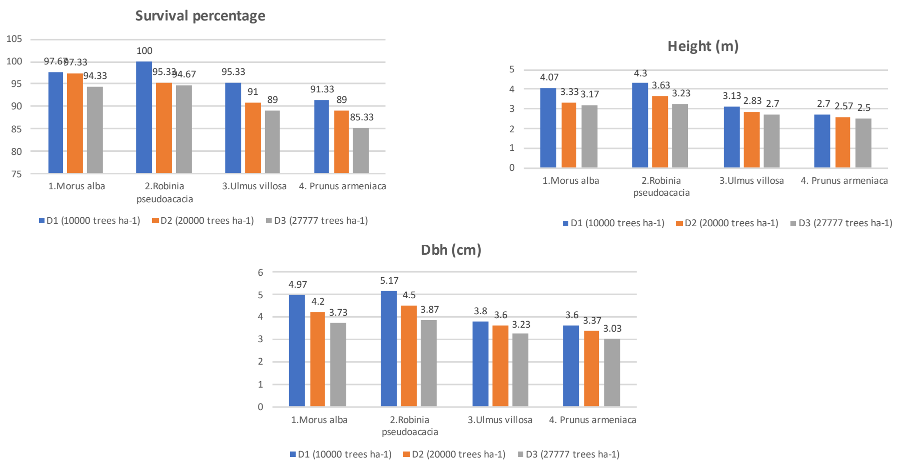


Fig.2. Effect of planting density on aboveground biomass (kg tree $^{-1}$ and tons ha^{-1}) of five years old *Morus alba* , *Robinia pseudoacacia, Ulmus villosa* and *Prunus armeniaca* plantations.

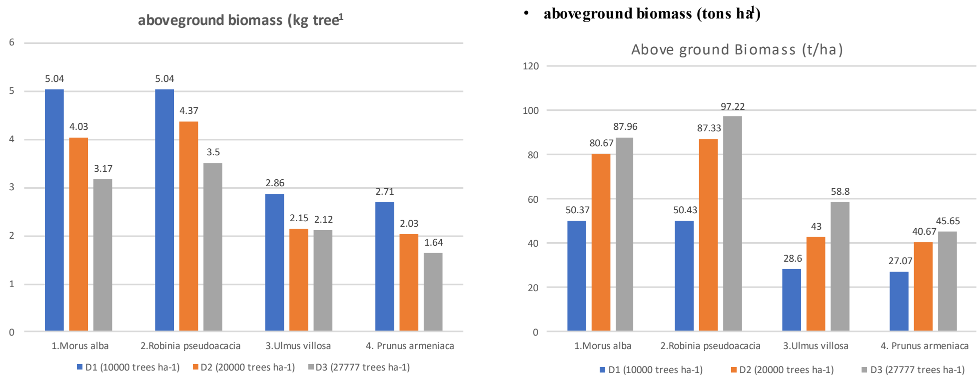
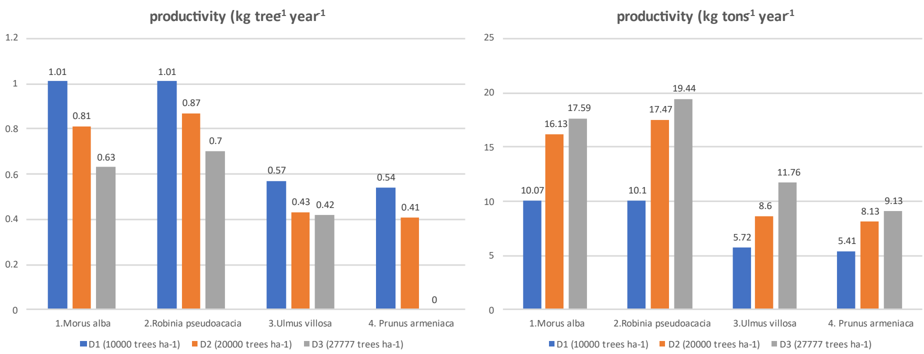


Fig.3. Effect of planting density on productivity (kg tree $^{-1}$ year^{1} and tons ha $^{-1}$ year^{1}) of five years old *Morus alba* , *Robinia pseudoacacia, Ulmus villosa* and *Prunus armeniaca* plantations.



6.13/T_6-111

Environmental and Economic Role of *Tectona grandis*: A Case Study

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Keywords: Teak plantation, economic importance, ecological benefits, CO_2 mitigation potential

1. Introduction

As a mitigation strategy to lower atmospheric carbon dioxide and boost farmers' net income, plantations are being considered. Many tropical nations are implementing agroforestry-based carbon storage programmes; however, it is challenging to quantify the potential for carbon storage. In the present study, the amount of carbon stored in the plantation, the potential to mitigate carbon from the atmosphere and the market value of a 6-year-old and a 4-year-old plantation in Chhattisgarh, India, is estimated.

2. Material and methods

The merchantable volume, market value, standing biomass, carbon storage and CO_2 mitigation potential were estimated in a 6-year-old and a 4-year-old plantation using a non-destructive method. The volume was estimated by girth and bole height, and per cubic feet volume was multiplied by market value to estimate market value. The biomass and carbon storage were estimated using a regression equation, and the value given by IPCC estimated CO2 mitigation potential.

3. Results and discussion

The result indicated that the six-year-old plantation has the potential to produce 89.29 ft^3 of the merchantable volume of timber with a market value of Rs. 1,29,470 - 6,25,119/- and the merchantable volume and market value produced in the 4-year -old plantation was 67.24 ft^3 and Rs. 97,493 - 4,70,726/-.

Table 1. Mean biomass, carbon storage, carbon mitigation potential, merchantable volume and market value of Teak plantation

Plantation	Biomass (t/ha±SE)	CS (t C/ha±SE)	CO_2 mitigation potential (t CO_2/ha±SE)	Merchantable volume (ft^3±SE)	Market value (ru)	
					Minimum	Maximum
4-year-old	309.00 ±26.86	127.36 ±11.15	467.40 ±40.91	67.24 ±4.65	97493	470726
6-year-old	434.67 ±28.05	179.59 ±11.67	659.08 ±42.84	89.29 ±4.95	129470	625119

Similarly, the biomass and carbon stored in a six-year-old plantation was 309.00 t ha^{-1} and 127.36 t C ha^{-1} and in the four-year-old plantation it was 221.99 t ha^{-1} and 91.29 t C ha^{-1}. The CO_2 mitigation potential was 335.04 t CO_2 ha^{-1} in a four-year-old plantation and 467.40 t CO_2 ha^{-1} in a six-year-old plantation. As India's forests are native to teak and it is cultivated as a high-priority species in many states, although its planting is only done on a small to moderate scale, the response in the Indian state is found to be better. The results revealed that, with the increase in the age of teak plantations, there is an increase in carbon sequestration in plantations with a higher economic and ecological return.

6.14/T_6-115

Influence of Biofertilizers on Seedling Growth and Vigour of Indian Redwood [*Soymida febrifuga* Roxb.]- A Lesser Known Tree

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Keywords: *Soymida febrifuga,* biofertilzer, seedling growth, Azospirillum, PSB

1. Introduction

Soymida febrifuga Roxb. popularly called as Indian Redwood, is one of the lesser-known tree species distributed naturally in the deciduous forests. Its occurrence is found to be random and less dense with poor natural regeneration. In the present study, influence of biofertilizers on growth and vigour of Indian redwood seedlings were assessed in the nursery.

2. Material and methods

The present investigation was conducted at Net House, College of Forestry, NAU, Navsari, Gujarat. For this nursery experiment, twenty-two treatments of six biofertilizers *viz*. Azotobacter, Azospirillum, Acetobacter, PSB, Pseudomonas and VAM in single and combinations including control, were adopted by following completely randomized design. Observations for growth and vigour parameters were recorded at 180 DAT and data were analysed by following CRD design.

3. Results and discussion

Seedlings of *S. febrifuga* treated with Azospirillum @ 5ml/plant + PSB @ 5ml/plant treatment achieved significantly maximum shoot length (16.01 cm) and collar diameter (4.90 mm), dry wet of plant (3.78 g) and seedling quality index (0.75) at 180 DAT. Present findings of growth and vigour

Table 1. Influence of biofertilizers on the growth and vigour parameters of *S. febrifuga* seedlings at 180 DAT

Treatments	Seedling height (cm)	Collar diameter (mm)	Dry weight of plant(g)	Seedling Quality Index (SQI)
T_1	11.57	2.83	1.15	0.20
T_2	12.94	4.13	2.70	0.54
T_3	12.87	4.20	2.30	0.49
T_4	13.60	4.15	2.02	0.39
T_5	12.27	3.93	1.52	0.31
T_6	13.47	4.10	2.48	0.51
T_7	12.98	4.20	1.98	0.37
T_8	13.80	3.94	1.95	0.36
T_9	14.66	4.38	3.21	0.59
T_{10}	11.93	4.04	1.76	0.35
T_{11}	13.44	4.11	1.71	0.30
T_{12}	13.07	4.33	1.25	0.24
T_{13}	14.16	4.25	2.33	0.39
T_{14}	16.01	4.90	3.78	0.75
T_{15}	12.55	4.15	1.56	0.32
T_{16}	10.64	3.03	1.75	0.30
T_{17}	13.34	3.73	2.52	0.46
T_{18}	13.44	4.17	2.20	0.43
T_{19}	12.27	3.84	1.72	0.36
T_{20}	12.37	4.03	1.75	0.38
T_{21}	13.08	4.07	2.13	0.39
T_{22}	13.09	3.31	2.10	0.28

Mean	13.07	3.99	2.07	0.40
SEm (±)	0.33	0.09	0.05	0.01
CD at 5%	0.95	0.27	0.14	0.04
CV (%)	4.42	4.05	4.19	6.36

parameters of seedlings in the combination of Azospirillum @ 5ml/plant + PSB @ 5ml/plant treatment resulted in significant increase in seedling growth and vigour attributes, where combine application of Azospirillum and PSB made synergistic effect to enhance the seedling growth in *S. febrifuga*. Such inference has also been reported in other tree species like *Gmelina arborea* (Maharana et al 2018) and *Aegle marmelos* (Mohan and Rajendran 2017). Among several biofertilizer treatments, seedlings treated with Azospirillum @ 5ml/plant + PSB @ 5ml/plant was found to be superior and this treatment may be used for raising quality seedlings of Indian Redwood in the nursery for timely transplanting or field planting.

Reference

Maharana R, Dobriyal MJ, Behera LK and Sukhadiya M 2018. Enhancement of seedling vigour through biofertilizers application in gamhar (*Gmelina arborea* Roxb.). *International Journal of Chemical Studies* **6**(5): 54-60.

Mohan E and Rajendran K. 2017. Effect of beneficial microorganism on quality seedling production of *Aegle marmelos* under nursery conditions. *TEJAS Thiagarajar College Journal* **2**(1): 28-39.

6.15/T_6-119

Assessment of Survival and Growth Performance of Tree Species in One Year Old Urban Plantation of Kumta Town in Uttara Kannada District of Karnataka

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Keywords: urban forests, plantation, lateritic soil, watering

1. Introduction

Urban forests play a vital role in managing ecosystem in the urban areas by improving the air quality, soil stability and development through sustainability. There are many challenges faced by urban forestry such as tree maintenance, tree survival, tree establishment, compactness of soil, public support, planting site inventory, minimizing costs, *etc.* The present study was conducted to study the growth attributes of one year old urban planation in Kumta town of Uttara Kannada district of Karnataka.

2. Material and methods

The experiment was held near Horticulture department in Kumta city. The area is of 2.5 hectare and Forest survey number- 440 /A. Soil is lateritic soil with more rocky area having soil pH 6.5 and Soil EC is about 0.001 dS /m. The plantation was made by Forest department in June 2018 under 'Greening Urban Area scheme' launched by Government of India. The area has 1050 tree individuals and the area is covered by lateritic soil with hard rocky surface. The plantation included 9 different species trees with spacing 7.5 x 7.5 m and each planting pit size is $1m^3$ with saucer burrow type of pit. After rainy season, fertilisers were applied and in summer watering has been done. The study area had lateritic soil with pH 6.5 it is neutral in nature and soil EC is about 0.001 dS/m, it is also favourable for growth of plants some regions of the study area soil depth is very shallow, in that area the growth of the plants was fairly low. Details of treatments (Tree species planted) were T_1- *Mangifera indica*, T_2- *Artocarpus heterophyllus*, T_3- *Syzygium cumini*, T_4- *Lagerstroemia speciosa*, T_5- *Vateria indica*, T_6- *Swietenia macrophylla*, T_7- *Parkia speciosa*, T_8- *Michelia champaca* and T_9-*Tamarindus indica.* Observations were recorded such as number of seedlings planted for each species, number of seedlings of each species survived, plant height, girth at collar, number of branches, plant percent and increment.

Table 1. Growth and survival of tree species planted in Urban area of Kumta town

Sl. No.	Tree species	Survival rate (%)	Height increment (%)	Girth increment (%)
1	*Mangifera indica,*	99.27	8.88	16.66
2	*Artocarpus heterophyllus*	98.34	9.58	26.22
3	*Syzygium cumini*	99.41	6.95	20.63
4	*Lagerstroemia speciosa*	97.64	8.90	15.67
5	*Vateria indica*	57.95	3.86	9.10
6	*Swietenia macrophylla*	100	13.90	34.90
7	*Parkia speciosa*	100	11.67	28.22
8	*Michelia champaca*	36.58	7.36	19.68
9	*Tamarindus indica*	100	1.57	5.94

3. Results and discussion

The results revealed that survival rate of species planted ranged from 36.58 to 100 per cent. *Swietenia macrophylla*, *Parkia speciosa*, *Tamarindus indica* these species have 100 per cent survival. While, survival per cent of other tree species was found to be better *viz.*, *Syzygium cumini* (99.41 %), *Mangifera indica* (99.27 %), *Artocarpus heterophyllus* (98.34 %) and *Lagerstroemia speciosa* (97.64 %). *Michelia champaca* reported lowest survival per cent (36.58 %) followed by *Vateria indica* (57.95 %). The lowest survival per cent of *Michelia champaka* may be due to lower adaptability towards coastal climatic conditions (Table 1). The growth increment rate ranged from 1.57 per cent to 13.90 per cent. All nine species showed good growth response with respect to climatic condition. Among these nine species *Swietenia macrophylla* had the highest increment rate with (13.90 %) followed by *Parkia speciosa* (11.67 %) and least (1.57 %) was reported in *Tamarindus indica.* Other species like *Mangifera indica* (8.88 %), *Artocarpus* heterophyllus (9.58 %), *Syzygium cumini* (6.95 %) and *Lagerstroemia speciosa* (8.90 %) showed moderate growth rate. *Vateria indica* showed least growth rate (3.90 %) followed by *Tamarindus indica* (1.57 %) (Table 1). Girth increment rate ranged from 5.94 per cent to 34.90 per cent. Among all the species *Swietenia macrophylla* reported highest girth increment rate (34.90 %) followed by *Parkia speciosa* (28.22 %). While, *Mangifera indica* (16.66 %), *Artocarpus heterophyllus* (26.22 %), *Syzygium cumini* (20.63 %) and *Lagerstroemia speciosa* (15.67 %) had moderate girth. *Tamarindus indica* had the lowest girth increment rate (5.94 %) followed by *Vateria indica* (9.10 %) (Table 1). Soil factor influences the growth of tree species, in some area of the study site, tree growth was good because of optimum soil depth and moisture content. Some area of the study site with shallow soil depth resulted in poor tree growth this may be due to less moisture availability to the roots of the seedlings

6.16/T_6-123

Propagation Techniques of Kiwifruit for Quality Planting Material

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Keywords: Kiwifruit, chinese gooseberry, cuttings, vegetative propagation

1. Introduction

Kiwifruit or Chinese gooseberry belongs to the genus Actinidia and family Actinidiaceae. It is a dioecious, deciduous and perennial fruiting vine, native to Southern China. Among all the species, *Actinidia chinensis* has a special economic importance owing to its high export quality. The fruits are rich in nutrition and helps improve the immunity against a number of diseases.

2. Material and methods

The experiment was laid out according to Randomized Block Design (RBD). Each treatment was replicated thrice times with 30 cuttings. Well matured dormant shoots of 25-30 cm length, 0.5- 1.0 cm thickness with at least 3 healthy bold buds were selected during mid-January to prepare hard-wood cuttings and the semi-hardwood cuttings were prepared in similar manner during mid- July retaining 2-3 leaves in these cuttings and were treated with 4000 ppm IBA.

3. Results and discussion

Among different cutting types, semi-hardwood cuttings performed better with respect to parameters *viz.* per cent rooted cutting and survival percentage etc. The higher rooting potential of semi-hardwood cuttings has been attributed to the endogenous auxin in tender vegetative growth. The percentage of rooted cuttings was higher in cuttings prepared in summer than the cuttings prepared in winter season. The presence of leaves in the cuttings at the time of planting not only supply nutrients but also specific root forming substance during rhizo-genesis which increases rooting per cent. Thus, the semi-hardwood cuttings of kiwifruit produced disease free and sound planting material more quickly and are less expensive beside requiring less space and skill.

6.17/T_6-124

Effect of Different Growing Media on Germination and Seedling Growth of Wild Almond (*Sterculia foetida* L.)

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Keywords: *Sterculia foetida*, growing media, germination, seedling

1. Introduction

Sterculia foetida L. is a tropical tree species belongs to the family Sterculiaceae which is also called as Java-Olive or wild almond tree. *S. foetida* L. can be easily raised from seeds. The tree is found in some parts of India but it is not found in many parts of the country. Hence, there is an urgent need for conserving rare tree species which is required (Rai, 2012).

2. Material and methods

The present investigation was conducted at Model Nursery of Medicinal and Aromatic plants of College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India, from June 2022. The experiment was laid out in Completely Randomized Design (CRD) with 6 treatments and 3 repetitions in which 10 seedlings per treatment per repetition were taken for study. Treatments were T_1: Control (clay soil), T_2: Soil: Sand (2:1), T_3: Soil: Sand (4:1), T_4: Soil: Vermicompost (4:1), T_5: Soil: Sand: Vermicompost (2:1:1) and T_6: Soil: Sand: Vermicompost (4:1:1).

3. Results and discussion

The best performance of seed germination and seedling growth is found with T_5: Soil: Sand: Vermicompost (2:1:1) which could be due to the fact that soil and vermicompost are high in organic matter which increases water and nutrient holding capacity of the medium for supply to the plant. Vermicompost is reported as having bioactive principles considered to be beneficial for root growth, root initiation, germination and growth of the plant (Bachman and Metzger, 2008), as also having a balanced composition of nutrients (Zaller, 2007).

References

Bachman GR and Metzger JD 2008. Growth of bedding plants in commercial potting substrate amended with vermicompost. *Biores Tech* **99**: 3155-3161.

Rai MK 2012. Silver nanoparticles: The powerful nano weapon against multidrug-resistant bacteria. *J. Applied Micro* **112**(5): 841-852.

Zaller JG 2007. Vermicompost as a substitute for peat in potting media: Effects on germination, biomass allocation, yields and fruit quality of three tomato varieties. *Sci Hort* **112**: 191-199.

6.18/T_6-128

Seedling Quality, Growth and Biomass of Sandalwood in Response to different Nutrient Sources

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Keywords: Sandalwood, host, nutrient application, seedling quality index

1. Introduction

Among the 16 species of the economically important genus *Santalum*, *S. album* L. or Indian Sandalwood is highly priced for its scented heartwood. Sandalwood's high economic worth provides enough incentive for farmers to grow it on a commercial scale. However, because of pilferage and the difficulties of field establishing sandal trees in new regions, the area under the tree is rapidly dwindling. Seedlings are not growing well during its seedling growth because of lack of proper nutrition to it. There is a need of providing the appropriate nutrition to the seedlings of Sandalwood in the nursery.

2. Material and methods

For experiment sand bed was prepared and seed of Sandalwood commonly treated with 500 ppm GA_3 dipping for 24 hours. After GA_3 treatment seeds were sown in sand bed. After good germination, averaged height plants were selected for experiment. Leucaena (*Leucaena leucocephala*) was used as a common host plant. The bio-fertilizer, vermicompost and NPK applied as per treatments. Five plants were randomly selected for taking observations of every treatment in all the three repetitions and the observation were recorded at monthly interval.

3. Results and discussion

The findings of research revealed that application of various source of nutrient on Sandalwood seedling at nursery stage significantly increased the growth parameters (seedling height, collar diameter, number of leaves and root length), fresh and dry biomass and seedling quality parameters. A constant increased in all parameters and variation among different treatments was observed during study period (30 to 180 days after transplanting). Seedling height, collar diameter, number of leaves per plant, fresh and dry weight of shoot, leaves and whole plant, seedling quality index (0.127), root length shoot length ratio (0.837) and shoot root ratio on dry weight bases (3.013) were recorded in T_{10} (1 g NPK + Vermicompost @ 25 g/ seedling). Similar results were also reported by Lamani et al. (2001) and Mishra and Channabasappa (2013).

Table 1. Effect of different source of nutrient on growth parameters of *Santalum album* L. seedlings at 180 DAT

Treatments	Seedling height (cm)	Collar diameter (mm)	Number of leaves	Root length (cm)
T_0	22.80	2.39	9.53	16.93
T_1	28.20	3.20	15.10	18.43
T_2	28.23	3.24	16.00	18.97
T_3	26.53	2.99	14.07	21.36
T_4	26.60	3.02	14.13	21.45
T_5	23.13	2.71	11.00	19.18
T_6	23.27	2.85	11.40	19.43
T_7	24.87	2.90	12.07	19.84
T_8	26.07	2.91	12.27	20.13
T_9	26.27	2.98	13.40	20.25
T_{10}	28.47	3.26	16.27	20.33
T_{11}	27.80	3.09	14.27	20.53
T_{12}	28.00	3.11	14.33	20.95
SEm.$\pm$	0.691	0.087	0.32	0.394
CD @ 5%	1.97	0.24	0.93	1.12
CV %	4.57	5.08	4.24	3.44

References

Lamani V K, Patil S K and Manjunath G O 2001. Growth of *Acacia auriculiformis* as influenced by N, P and K fertilizer. *Karnataka Journal of Agricultural Science* **17**(4): 872-874.

Mishra R K and Channabasappa KS 2013. Effect of integrated nutrient management on *Tectona grandis* (Linn.f.) with special reference to biofertilizers. M.Sc. (Fort.) Thesis, University of Agricultural Science. Dharwad, Karnataka (India).

6.19/T_6-130

Effect of Root Pruning and Nitrogen Application on Growth Performance of *Celtis australis* L. Seedlings in Garhwal Himalaya, Uttarakhand, India

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Keywords: Root pruning, white root regeneration, chlorophyll content, survival percentage

1. Introduction

Root pruning helps in improving tree root and shoot performance and physiological responses which helps to stimulate the new roots which is necessary to carry on growth. Root pruning also reduces the oldest growth balance of trees and change their hormone levels and nutrient distribution and also assimilation abilities. Plants need nutrients to grow and fertilizers are a good source of nutrients. Nitrogen is an essential and important element which is required for plant growth and their development.

2. Material and methods

The field experiment was conducted in the experiment fields of College of Forestry, Ranichauri situated at an altitude of approximately 1850 m asl between 30˚15˚N latitude and the mild hills of Uttarakhand in Tehri Garhwal**,** The field experiment was laid out in factorial randomized block design which had 3 root pruning treatments (control, at 6 cm and at 12 cm root pruning from collar region) and 4 nitrogen application treatments (control, 50, 100, 150 Kg N ha^{-1}) with three replications at College of Forestry, Ranichauri.

3. Results and discussion

The results of this study showed that growth, physiological parameters and nutrient parameters *viz.* shoot length, root length, collar diameter, number of leaves per plant, dry weight of shoot, root and leaves, survival percent, white root regeneration, chlorophyll content and NPK content and uptake was significantly ($p<0.05$) enhanced by the root pruning and nitrogen application. However, no significant difference was observed in interaction of root pruning and nitrogen application for shoot and root length. The root pruned at 12 cm from collar region and nitrogen at the rate of 100 Kg ha^{-1} gave the best results for growth of *C. australis* seedlings whereas, the control treatments of both factors showed the least values for growth and physiological attributes.it can be concluded that root pruning and nitrogen application has enhanced the growth performance and physiological characteristics of *Celtis australis* seedling. Nitrogen application and root pruning combinations recovered the plants from the stress condition and enhanced the morphological as well as physiological characteristics of seedlings. Such inference was also observed in *Acacia catechu* (Vasishth et al 2007).

References

Vasishth A, Kaushal P, Kaushal AN and Dutt B 2007. Effect of root pruning and nitrogen application on post planting survival, growth and establishment of *Acacia catechu* Willd. seedlings. *Indian Forester* **133**(8):1027-1043.

6.20/T_6-131

Community Structure of Lesser-Known Tree Species, *Dalbergia lanceolaria* L. f., in Tropical Deciduous Forest

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Keywords: *Dalbergia lanceolaria*, Lesser-Known Trees, Importance value index, vulnerable

1. Introduction

Dalbergia lanceolaria L. f. is one of the lesser known tree species distributed in deciduous forests. This species is used as minor timber for small constructions and different parts of plant are used in ayurvedic medicine. A recent IUCN assessment observed the declining population throughout the world and it is already reached 'vulnerable' category in Sri Lanka. The ecological structure of this species is scanty; therefore, the present study was undertaken to study the stand structure and natural regeneration of the species in the natural forest.

2. Material and methods

A study was carried out in the natural forests of northern most region of the Western Ghats, South Gujarat during 2021. Fifteen quadrates of 20 x 20 m were laid out randomly across the *Dalbergia lanceolaria* populations for stand structure. A regeneration plot of 1m x 1m were laid out around the selected trees (N=15) at different distances and directions from each tree to study the natural regeneration patterns in the studied population. Ecological parameters were estimated as per standard formulae.

3. Results and discussion

Composition of studied *D. lanceolaria* population showed that there were 20 different tree species (including *D. lanceolaria*) belonged to 13 families, 17 genera. Importance value index (IVI) recorded to be highest for *D. lanceolaria* (IVI-108.31), which occupied the upper storey of the deciduous forests.

Table 1. Phyto-sociological attributes of *Dalbergia lanceolaria* and its associated tree species

Sl. No.	Species/ Family	*n*	IVI	Sl. No.	Species/ Family	*n*	IVI
1	*Dalbergia lanceolaria* Fabaceae	37	108.31	11	*Madhuca longifolia* Sapotaceae	6	18.88
2	*Adina cordifolia* Rubiaceae	2	6.71	12	*Mangifera indica* Anacardiaceae	1	4.11
3	*Bahunia malbarica* Fabaceae	1	3.01	13	*Miliusa tomentosa* Annonaceae	5	15.81
4	*Butea monosperma* Fabaceae	5	11.91	14	*Ougeinia oojeinensis* Fabaceae	1	3.77
5	*Casearia* spp. Flacourtiaceae	2	4.25	15	*Schliechera oleosa* Sapindaceae	1	2.84
6	*Dalbergia latifolia* Fabaceae	6	14.14	16	*Spathodea roxburghii* Bignoniaceae	2	6.37
7	*Dalbergia paniculata* Fabaceae	1	3.51	17	*Tectona grandis* Lamiaceae	12	34.27
8	*Diospyrus melanoxylon* Ebenaceae	2	5.82	18	*Terminalia bellirica* Combretaceae	2	12.08
9	*Garuga pinnata* Burseraceae	6	16.22	19	*Terminalia tomentosa* Combretaceae	8	22.15
10	*Gmelina arborea* Lamiaceae	1	2.92	20	*Wrightia tinctoria* Apocynaceae	1	2.89

Further, this species is closely associated with *Tectona grandis* (IVI of 34.27), *Terminalia tomentosa* (IVI of 22.15), *Madhuca longifolia* (IVI of 18.88) and *Garuga pinnata* (IVI of 16.22). Distribution of this species in the studied population is found to be negatively skewed. Among recorded individuals, 48.65 % per cent of stems belonged to 160-190 cm girth class. It is also recorded that most of the individuals of *D. lanceolaria* are regenerated by root suckers. Natural regeneration count of *D. lanceolaria* was found to be poor and its distribution was more near the base (0.93 m^{-2}) at northern direction (0.67 m^{-2}). Information provided here may be useful for ecological studies and protection of this species.

6.21/T_6-134

Effect of different Potting Media on Seedling Growth of Teak (*Tectona grandis* Linn.f.)

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Keywords: *Tectona grandis,* planting stock, potting media, production

1. Introduction

Teak is one of the most celebrated timber species of the tropics. Raising good quality seedlings requires technical skills, an adequate attention in developing healthy nursery plant stock will ensure their better establishment and survival in the field. In this context of containerized seedling production, the best potting media is one of the important inputs and is primarily responsible for healthy seedling production. Hence, the present study was undertaken to find the best potting media for raising good-quality planting stock.

2. Material and methods

Seedlings were subjected to the different potting media composition treatments (T1- Soil+ coir pith compost+ FYM, T2- Soil+ coir pith compost+ vermicompost, T3- Soil+ rice husk+ vermicompost, T4- Coir pith+ vermiculite+ perlite, T5- Soil+ sand+ FYM (Control)) with four replications. In all the potting media treatments three different ingredients were taken by volume in the ratio 2:1:1. Seedling growth observation recorded at monthly interval. Completely Randomised Design were used in this experiment.

3. Results and discussion

The present study revealed that the growing media treatment T3 (Soil+ Rice husk+ vermicompost in 2:1:1 ratio) was significantly superior throughout the seedling growth in almost all growth characteristics of the teak seedlings like shoot growth, collar diameter and total seedling length (Table 1). Overall, T3 combination growing media (Soil+ Rice husk+ vermicompost in 2:1:1 ratio) showed best seedling characteristics among all the other treatments. This may be due to rice husk created a lighter and friable growth medium which resulted in an almost loose root plug formation. The treatment T3 recorded the maximum root dry weight (3.14 g) root dry weight was recorded followed by T2 (2.93 g) which were on par with each other and the lowest root dry was recorded in T4 (0.52 g). Both from the production /seedling quality and from the economic point of view, the treatment M3- Soil+ rice husk+ vermicompost was the best.

Table 1. Effect of different potting media on the growth parameters of *Tectona grandis* seedlings

Treatment	Shoot length (cm)	Collar diameter (mm)	Total seedling length (cm)	Root dry weight (g)
T1	15.75^{b}	2.66^{b}	30.50^{b}	1.39^{b}
T2	17.37^{b}	2.60^{b}	39.37^{a}	2.93^{a}
T3	19.94^{a}	3.41^{a}	40.41^{a}	3.14^{a}
T4	7.06^{c}	1.58^{c}	31.87^{b}	0.52^{c}
T5 (Control)	19.87^{a}	2.66^{b}	42.50^{a}	3.11^{a}
F value	74.94**	26.81**	15.09**	28.43**
P value	<0.01	<0.01	<0.01	<0.01
CD (0.05)	1.75	0.36	4.11	0.64

**Significant at 1% level; *Significant at 5% level

6.22/T_6-148

Impact of Pre-sowing Seed soaking on Germination, Growth and Biomass characteristics of Malabar Embelia (*Embelia tsjeram-Cottam*)

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Keywords: Malabar Embelia, germination, growth, biomass

1. Introduction

Embelia tsjeram-cottam, also called as Malabar Emelia, is a significant, red-listed medicinal plant of India with moderate demand in the domestic and international markets according to IUCN, Switzerland (Kirtikar and Basu 1935). It is a member of the Myrsinaceae family. *E. tsjeram-cottam* is a diverse plant that can be anything from a little shrub that grows 1 to 2 metres tall to a small tree or even a twining climbing plant in hilly regions of India, it is populated. It is also found in the Himalayas, between Kashmir and Sikkim, at elevations of 400 to 1600 m. It is an endangered medicinal plant valued for its digestive, thermogenic, carminative, depurative, anthelmintic, and laxative properties since immemorial time and frequently present in deciduous to semi-evergreen forests (Bhattacharjee 2000).

2. Material and methods

The investigation was carried out at the College of Forestry Dapoli, Ratnagiri during 2017-18. The experimental site is situated at an altitude of 252 metres above mean sea level and 17.7677 degrees north latitude and 73.1910 degrees east longitude in Maharashtra state's hilly region. The required seed material was collected from the village Tulshi, Tahasil Khed, Dist. Ratnagiri. The outer mucilaginous covering present in the seeds was removed. The scarified seeds were subjected to various pre-soaking treatments.

Table 1. Impact of scarification and seed soaking treatments on seed germination parameters of *Embelia tsjeram-cottam.*

Treatments	Days to first germination	Germination (%)	GRI	MDG	PV	GV
T1	9.45	2.06	0.05	0.02	0.03	1.45
T2	3.06	10.63	0.29	0.13	0.15	8.75
T3	4.89	9.36	0.24	0.11	0.12	8.56
T4	7.06	7.94	0.22	0.09	0.11	7.13
T5	9.31	9.36	0.23	0.11	0.14	7.57
T6	1.70	4.76	0.12	0.06	0.06	4.21
T7	7.22	5.88	0.14	0.07	0.11	5.25
T8	1.45	5.40	0.16	0.06	0.08	4.53
Mean	5.52	6.92	0.32	0.15	0.10	5.93
$SE_{m\,(\pm)}$	0.05	1.17	0.04	0.01	0.01	1.18
$CD_{0.05}$	0.14	3.55	0.13	0.04	0.04	3.58

GRI=Germination rate index; MDG=Mean daily germination; PV=Peak value; GV=Germination value; T_1=Scarification control; T_2= Scarification +soaking seeds in GA3 750 ppm for 24 hours; T_3=Scarification +soaking seeds in Ethylene 50 ppm for 24 hours; T_4=Scarification +soaking seeds in KNO3 1.0% for 24 hours; T_5=Scarification +soaking seeds in H2SO4 2.0% for 24 hours; T_6=Scarification +soaking seeds in HCL 2.0% for 24 hours; T_7=Scarification + soaking seeds in H2SO4 2.0%+GA3 750 ppm for 24 hours; T_8=Scarification +soaking seeds in HCL 2.0% + GA3 750 ppm for 24 hours

3. Results and discussion

The data pertained to the impact of scarification and seed soaking treatments on seed germination parameters of *E. tsjeram-cottam.* was found to be significant and presented in Table 1. The minimum days required for first germination (1.45 days) were recorded in the treatment T8 i.e., scarification + soaking seeds in HCL 2.0% + GA_3 750 ppm for 24 hours (T8) while, maximum % germination (10.63), germination rate index (0.29), mean daily germination (0.13), peak value germination (0.15) and germination value (8.75) were recorded in treatment T2 *i.e.*, scarification + soaking seeds in GA_3 750 ppm for 24 hours. Similar results of increased germination attributes such as % germination, germination rate index, mean daily germination, peak value germination and germination value were observed in *E. ribes* (Shruthi et al 2016), an endangered tree species where GA_3 at 100 ppm recorded maximum germination (2.07%) compared to control (0.17%).

References

Bhattacharjee SK 2000. *Handbook of medicinal plants*. Aavishkar Publishers.

Kirtikar KRBB, Basu BD 1935. Indian medicinal plants.

Shruthi AM, Shetty GR, Ganapathi M, Vaishnavi BA 2016. Standardization of seed and vegetative propagation techniques in *Embelia ribes* Burm f.: An endangered medicinal plant. *Research on Crops* 17(4):793

6.23/T_6-150

Effect of Different Potting Media on Germination and Growth Attributes of *Zanthoxylum rhetsa:* Uncultivated, Lesser-Known Wild Spice of Western Ghats, India

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1. Introduction

Zanthoxylum rhetsa, known as Indian prickly ash is a species of angiosperm of the family Rutaceae and with its native range Tropical Asia to North Australia. The indigenous communities of the Konkan use the pericarp as a spice, particularly with seafood dishes (Patil et al 2014). Also, it is used traditionally in eastern Himalayas and yet underrated (Yaipharembi et al 2022). This wood is used for traditional Ramayana wooden sculptures in Indonesia. Also, *Z. rhetsa* recently proved that it has excellent prospects to create drugs against leukaemia and diabetics (Quan et.al. 2022). In India fruiting season is September to November but can be differ with different localities (Patil et al 2014). Soil is now a days getting scarce natural resource and climate change also leading stress on availability of natural potting medias. Until now this species is harvested from wild only. So, it is necessary to study the nursery aspect of this unexploited spice in various media combinations hence, with this view present investigation was carried out.

2. Material and methods

This study was carried out during 2016-2017 as a part of M.Sc. (Forestry) programme at the College of Forestry, Dr. Balasheb Sawant Konkon Krishi Vidyapeeth, Dapoli, situated on the west coast of Maharashtra state in north Western Ghats. The soil is lateritic, porous, and acidic in reaction having pH range of 5.6 to 6.5. We have collected wild ripen fruits and pre-treated hundred good seeds for each treatment in hot water with 5% H2SO4 Five min. Treatments are different potting medias with different combinations as given in table no. 1, with three replications each with Fifty seedlings per treatment per replication. Seed germination parameters, seedling growth parameters and absolute growth index were calculated. We set the experiment in RBD design and all collections were evaluated and compared for the given parameters. For this purpose, mean values of collections were compared with critical difference (CD) values, which were calculated separately for each parameter at 5% level of significance.

3. Results and discussion

At 80 days after sowing, per cent germination was significantly influenced by different potting media treatments. The highest per cent germination was recorded in T1 [Control – Soil + FYM (2:1)] (45.33 %) and the lowest germination per cent was recorded in T3 [Soil + FYM (1:2)] (33.33 %). Higher germination in treatment T1 may be because compost is non-toxic, NPK rich, adequate aeration and moisture. Sand as a germination substratum is preferred for tree species having large seeds because aeration in sand is best. However, *Z. rhetsa* has a hard seed coat, which may need constant moisture conditions to soften it, which is not present in sand. All treatments showed almost 100% survivals after six months. After six months after sowing, T1 [Soil + FYM (2:1)] performed well and significantly different than many other treatments in parameters like height, cumulative per cent increment in height (64.65 %), number of leaves, cumulative per cent increment in number of leaves (950.669 %), shoot biomass (fresh and dry weights) also root length with 17.01cm. for most of these parameters T1 [Soil + FYM (2:1)] is at par with T2 [Soil + Vermicompost (1:1)]. But for root weight parameters were significantly higher in T2 [Soil + Vermicompost (1:1)]. might be because vermicompost represents hormone-like activity thus increases the number of roots, thereby, enhancing nutrient uptake. Vermicompost contains mucus which prevents nutrients from washing away, holds moisture better for boosting plant growth (Singh et al 1976). Lowest growth parameters are by T4 media [Soil + Cocopeat (1:1)] in parameters like height, The cumulative per cent increment in height (37.29

%), number of leaves, also showed minimum shoot biomass (fresh and dry weights) growth and root weight [fresh (3.96 gm) and dry weight (2.19 gm)]. During 151-180 days, the highest Absolute growth rate (AGR) was recorded in the treatment T1 [Soil + FYM (2:1)] (0.486 cm/day) which was significantly superior over all the rest of the treatments. T4 [Soil + Cocopeat (1:1)] recorded the lowest AGR (0.219 cm/day).

Table 1. Effect of different potting media on germination and growth of *Z. rhetsa*

a

Treatments	Germination (%); 80 DAS	Seedling height parameter at 180 days		Seedling leaves	
		height (cm)	% Increment	No. of leaves per seedling*	% increment **
T1	45.33 (28.43)	37.10	64.65	26.87	989.06
T2	40.66 (26.80)	33.02	55.77	24.20	1070.78
T3	22.66 (19.67)	30.44	61.82	25.07	944.46
T4	27.33 (21.69)	24.18	37.29	16.27	713.35
T5	36.00 (25.10)	31.22	51.70	23.73	917.27
T6	31.33 (23.31)	28.50	55.70	23.47	851.24
T7	34.00 (24.35)	31.67	43.44	24.27	628.08
Mean	16.65	30.88		22.69	
S.Em ±	1.73	0.59		2.11	
CD at 5%	5.36	0.53		1.88	

b

Treatments	Shoot Dry weight (gm)	Root length (cm) after 180 days	Root Dry weight (gm)	Absolute growth rate (AGR) (cm/day) 151-180 days
T1	10.15	17.01	2.53	0.486
T2	9.43	13.96	3.06	0.394
T3	9.37	12.96	2.39	0.388
T4	7.78	13.63	2.19	0.219
T5	9.06	13.76	2.77	0.355
T6	8.60	13.20	2.25	0.340
T7	9.54	12.97	2.36	0.320
Mean	9.13	13.92	2.51	0.357
S.Em ±	0.87	1.54	0.41	
CD at 5%	0.77	1.93	1.93	

T1: Control – Soil + FYM (2:1); T2: Soil + Vermicompost (1:1); T3: Soil + FYM (1:2); T4: Soil + Cocopeat (1:1); T5: Soil + FYM + Cocopeat (1:1:1); T6: Soil + Vermicompost + Cocopeat (1:1:1); T7: FYM + Vermicompost + Cocopeat (1:1:1); (Figures in the parentheses are arc sine transformed values); *Number of leaves observation recorded at monthly interval from date of sowing; **Increment in No. of Leaves over initial observation in per cent; Abbreviation used – DAS: Days after sowing; cm: Centimetres; gm: Gram

References

Patil J B, Shivanna H and Hegde K 2014. Seed source variation on fruit and seed traits of *Zanthoxylum rhetsa*-a medicinal tree under high exploitation in Central Western Ghats, India. *International Journal of Pharmacy & Life Sciences*, 5(12).

Quan N V, Anh L H, Lam V Q, Takami A, Teschke R, Khanh T D and Xuan T D 2022. Anti-diabetes, anti-gout, and anti-leukemia properties of essential oils from natural spices *Clausena indica*, *Zanthoxylum rhetsa* and *Michelia tonkinensis*. *Molecules* **27**(3): 774.

Singh J and Mann M S 1976. Effect of various planting media on the growth of trifoliate orange seedling. *Punjab Horticultural Journal* **16**(2):108– 112.

Yaipharembi N, Huidrom E and Singh H B 2022. Traditional importance, phytochemicals and pharmacological properties of Indian Prickly Ash (*Zanthoxylum rhetsa* (Roxb.) DC.): A review. *Pleione* **16**(2): 115 - 129. 2022.

6.24/T_6-167

Effect of Biopriming on Seed Germination, Growth and Biomass of Waras (*Heterophragma quadriloculare*)

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Keywords: Biopriming, growth hormone, Azotobactor

1. Introduction

Heterophragma quadriloculare (Roxb.) K. Schum. belongs to Bignoniaceae is a large deciduous tree endemic to Peninsular India. The wood and leaves have many medicinal properties. Bio-priming is new technique of seed treatment that integrates biological (inoculation of seed with beneficial organism to protect seed) and physiological aspects (seed hydration) of disease control. Biopriming improved the seedling vigor, germination percentage, speed of germination, growth and development. Bio-priming agents directly release growth promoting hormones *viz*., indole acetic acid, gibberellin, and cytokinin or stimulate their production in the plant. They also improve the availability of minerals *viz*., nitrogen, phosphorous, potassium, and Iron whereby enhance the plant growth and development. Seed priming is used as a tool to increase speed and uniformity of germination and improve final growth.

Therefore, seed priming alone or in combination with low dosage of fungicides and/or biocontrol agents can be used to improve the rate and uniformity emergence of seed and reduce damping-off disease. The species is regionally categorised as Vulnerable as per the IUCN classifications hence, it is protected in forest areas. No other particular conservation effort is known for this species, hence as an approach towards this information the present study was conducted.

2. Material and methods

Seeds of Waras (*H. quadriloculare* Roxb.) were collected from Rajpipla region of Gujarat. Pre-soaking of seeds will be done in water for 24 hours. Then the seeds were soaked in various bio-prims *viz*., T_1- Control, T_2- Azotobactor 2%, T_3- Phosphate solubilizing bacteria (PSB) 2%, T_4- Potassium mobilizing bacteria (KMB) 2%, T_5- Pseudomonas 2%, T_6- Trichoderma 2%, T_7- Azotobactor + PSB + KMB 2% (0.66% Each), T_8- Pseudomonas + Trichoderma 2% (1% Each) and T_9- Azotobactor + KMB + PSB + Pseudomonas + Trichoderma 2% (0.40% Each). After mixing seeds shall be put at the room temperature for the 6 hours. Then seed shall be sown into polybag as per repetition/treatment. The observations on various germination, growth and survival were recorded at 180 Days After Sowing (DAS).

3. Results and discussion

It was found that the germination percent and survival percentage of Waras (*H. quadriloculare* Roxb.) was not significantly influenced by different bio primers. Whereas, growth and biomass parameters of Waras (*H. quadriloculare* Roxb.) significantly influenced by different bio primers. The plant height (30.18 cm), fresh weight of root (29.93 g), dry weight of root (9.85 g), fresh weight of shoot (24.45 g) and dry weight of shoot (10.12 g) were was recorded significantly maximum in T_9 treated with [Azotobactor + KMB + PSB + Pseudomonas + Trichoderma 2 % (0.40 % Each] (Table:1). The second-best treatment in order to response of different growth and biomass parameters was T_7- Azotobactor + PSB + KMB 2% (0.66% Each). An application of different biopriming treatment individually and with combination of one or more bioprimers showed enhancement in different growth and biomass parameters of the species (Sukanya et al 2018).

Individual bioprimer enhanced growth, biomass and vigour indices as compared to control. However, the germination attributes were not significantly influenced by various bio primers.

Table 1. Effect of biopriming on germination, survival, growth, and biomass of *H. quadriloculare* Roxb.)

Treatments	Germination (%)*	Survival (%)+	Plant height (cm)	Fresh weight root (g/plant)	Fresh weight shoot (g/plant)	Dry weight root (g/plant)	Dry weight shoot (g/plant)
T_1	78.33	73.33	15.08	9.84	7.98	2.82	2.50
T_2	85.00	70.00	21.50	17.76	14.90	4.69	4.44
T_3	80.00	70.00	20.68	16.83	14.45	4.15	4.40
T_4	78.33	63.33	20.39	15.75	11.85	4.09	4.20
T_5	80.00	76.67	20.35	14.51	10.76	3.57	3.04
T_6	80.00	68.33	21.70	13.61	8.59	3.01	2.76
T_7	86.67	65.00	20.50	22.02	17.98	5.40	5.19
T_8	85.00	68.33	20.29	14.48	11.60	3.81	3.51
T_9	90.00	66.67	30.18	29.93	24.45	10.12	9.85
S.Em. $\pm$	3.64	7.35	0.74	0.89	0.66	0.18	0.17
C.D. at 5 %	(NS)	(NS)	2.21	2.63	1.95	0.53	0.52
C.V. %	9.56	22.27	6.07	8.92	8.35	6.72	6.78

Reference

Sukanya V, Patel RM, Suthar KP and Singh D (2018). An overview: mechanism involved in bio-priming mediated plant growth promotion. *International Journal Pure and Applied Biosciences* **6**(5): 771-783.

6.25/T_6-168

Seed Germination and Seedling Growth of *Bauhinia malabarica* Roxb., a Species of Conservation Concern

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Keywords: Vulnerable, germination, seedling vigour

1. Introduction

Bauhinia malabarica is a small to moderate sized deciduous Lesser Known and Threatened tree species and vulnerable in Gujarat according to IUCN. Seed coat of this tree species is very hard and does not germinate easily in natural habitats. Further, the seedling growth in initial stage is slow. Thus, the present experiment was conducted to evaluate the effect of pre-sowing treatments on seed germination and early seedling vigour in *B. malabarica.*

2. Material and methods

For the trial, Completely Randomized Design with four repetitions and six different pre-seed treatments were adopted for assessment of seed germination and for seedling growth and vigour study. For germination trial, treated seeds (100 seeds/ treatment/ repetition) were sown in the tray containing soil: sand: farm yard manure (2:1:1 ratio) and after 30 days of sowing, seedlings were transferred into polythene bags having same media of germination for growth and vigour study.

3. Results and discussion

Results showed that significantly maximum germination, mean daily germination, germination value and germination rate index recorded in soaking of seeds in conc. H_2SO_4 for 60 minutes treatment. However, maximum peak value of germination was recorded in soaking of seeds in conc. H_2SO_4 for 90 minutes whereas minimum mean germination time was recorded in soaking of seeds in conc. H_2SO_4 for 30 minutes. The growth and vigour parameters of *B. malabarica* seedlings at 180 days after transplanting showed maximum shoot height, collar diameter, total fresh weight of plant, total dry weight of plant, total leaf area and seedling quality index in soaking of seeds in conc. H_2SO_4 for 60 minutes treatment. Soaking of seeds in conc. H_2SO_4 for 60 minutes was found best treatment for seed germination as well as seedling growth and vigour of *B. malabarica.*

Table 1. Influence of pre-sowing seed treatments on germination parameters of *B. malabarica*

Treatments	G%	MDG	PV	GV	MGT	GRI
T1	59.25	2.12	**5.63**	12.95	8.06	8.90
T2	72.00	2.57	8.33	21.69	7.24	8.91
T3	75.25	2.69	8.19	22.48	7.61	9.45
T4	69.25	2.48	8.51	21.53	7.33	7.76
T5	4.50	0.16	0.33	0.06	8.40	0.80
T6	72.00	2.57	8.28	21.44	7.38	8.18
Mean	58.71	2.10	6.55	16.69	7.67	7.34
SEm (±)	2.09	0.12	0.30	0.80	0.46	0.30
CD @ 5 %	6.25	0.37	0.90	2.39	N/A	0.91
CV (%)	7.11	11.63	9.14	9.57	11.87	8.26

T1- Soaking of seeds in hot water for 24 hrs, T2- Soaking of seeds in conc. H_2SO_4 for 30 minutes, T3- Soaking of seeds in conc. H_2SO_4 for 60 minutes, T4- Soaking of seeds in conc. H_2SO_4 for 90 minutes, T5- Soaking of seeds in cow dung slurry for 24 hrs, T6- Soaking of seeds in conc. H_2SO_4 for 120 minutes

6.26/T_6-170

6.26/T_6-170

Techniques for Production of Quality Planting Material- Poplar

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Keywords: Poplar, quality planting material, vegetative propagation

1. Introduction

Quality planting material - The production of uniform, healthy, disease-free planting material raised with an overall goal to raise the physiological and phytosanitary quality of the plant available to stakeholders to increase productivity. Poplar belongs to genus Populus and family Salicaceae. In India, about 225 clones of various poplars have been introduced, tested and some of them have performed very well. Poplar is a multipurpose tree species and adopted in different land use systems for production of raw materials for plywood, match box industries *etc*. For commercial production of quality planting materials of poplar, vegetative propagation through cutting is recommended and adopted.

2. Material and methods

The review pertaining to this study has been collected from library, google search. The available literature studies have been compiled and interpreted to find out the most suitable techniques adopted in poplar for quality planting material.

3. Results and discussion

Review collected from different literature for production of quality planting material of poplar. Overall review shows that for meeting requirement of quality planting material different techniques of plant propagation such as cutting and hydroponics are used and these techniques are promising for producing true to type plants. Poplar in warmed cuttings than the non-warmed and control cuttings at 29 DAS, recorded maximum number of adventitious roots (4.7 ± 0.6), maximum root length (182 ± 17 mm), root dry weight (77 ± 11 mg/plant) and percentage of rooted cuttings (100 %) with minimum number of fallen leaves per plant (1.6 ± 0.2) of (Shibuya et al 2013). In both fertilized and un-fertilized plants treatment, two-bud cuttings with thicker stems resulted in more roots than thin cuttings (Bohlenius et al 2017). In hydroponics technique among cutting of different seven clone highest values of stem height (42 ± 1.52 cm), dry matter root (0.07 ± 0.00 g) and shoot (0.43 ± 0.02 g) in *P. euphratica* Olivier and the lowest values of all parameters were obtained in *P. capsica* Bornmuller. The highest root length (25.87 ± 2.12 cm) was observed in clones of *P. nigra* sub sp. *betulifolia* (Pursh) W. Wettstein clone 17/13 *P. deltoides* Lux whereas maximum stem diameter was noted in *P. deltoides* Samsun and *P. alba* Linnaeus clone 49/9 (4.49 ± 0.07 mm; Ahmadloo et al 2018).

Reference

Bohlenius H, Fransson T, Holmstrom E and Salk, C. (2017). Influence of cutting type and fertilization in productionof containerized Poplar plants. *Forests* **8**: 164.

Shibuya T, Tsukuda S, Tokuda A, Shiozaki, S, Endo R and Kitaya Y (2013). Effects of warming basal ends of Carolina poplar (Populus 3 canadensis Moench.) softwood cuttings at controlled low-air-temperature on their root growth and leaf damage after planting. *J. For. Res.* **18**: 279–284.

Ahmadloo F, Calagar M, Salehi A, Ggoodarzi GR (2018). Investigation of rooting and growth characteristics of poplar clones in hydroponic and soil cultures. *J. For. Sci*. **64**: 207–215.

6.27/T_6-171

Assessment of Pre-Sowing Treatments on Seed Germination in Lesser Known Threatened Tree-Kamala [*Mallotus philippinensis* (Lam.) Mull. Arg.]

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Keywords: *Mallotus philippinensis*, seed treatment, gibberellic acid

1. Introduction

Mallotus philippinensis, commonly known as Kamala, Kampillaka and Kapila, is one of the lesser known threatened tree species distributed mainly in the tropical and subtropical forests of the India. Propagated mainly through seeds and the rate of natural reproduction is very poor, nearly 30 per cent due to hard seed coat. In the present study, influence of pre-sowing treatments on seed germination of Kamala was assessed in the nursery.

2. Material and methods

The present investigation was conducted at College of Forestry, NAU, Navsari, Gujarat during 2022. For this experiment, fourteen treatments of pre-sowing seeds treatments including control and three repetitions were adopted by following completely randomized design. Treatment includes-T1:Control (no pre-sowing treatment); T2:Soaking seeds in normal water for 12 hrs.; T3:Soaking seeds in normal water for 24 hrs.; T4:Soaking seeds in normal water for 48 hrs.; T5:T2 + Soaking seeds in GA3 solution @ 50 ppm for 30 min.; T6:T2 + Soaking seeds in GA3 solution @ 100 ppm for 30 min.; T7:T2 + Soaking seeds in GA3 solution @ 150 ppm for 30 min.; T8:T2 + Soaking seeds in GA3 solution @ 200 ppm for 30 min.; T9:T2 + Soaking seeds in GA3 solution @ 50 ppm for 60 min. T10:T2 + Soaking seeds in GA3 solution @ 100 ppm for 60 min.; T11:T2 + Soaking seeds in GA3 solution @ 150 ppm for 60 min.; T12:T2 + Soaking seeds in GA3 solution @ 200 ppm for 60 min. T13:Soaking seeds in cow dung slurry for 24 hrs.; T14:Soaking seeds in cow dung slurry for 48 hrs. Observations for germination parameters were recorded for 30 days.

Table 1. Pre-sowing treatments effect on germination attributes of *M. philippinensis*

Treatment	G (%)	MDG	PV	GV	GRI
T_1	29.00±9.85	0.85±0.29	1.10±0.50	1.04±0.81	15.92±8.55
T_2	36.33±7.51	1.07±0.22	1.92±0.07	2.05±0.43	28.98±3.07
T_3	42.67±5.51	1.25±0.16	2.17±0.57	2.78±1.07	34.18±6.96
T_4	46.00±7.94	1.35±0.23	2.46±0.74	3.42±1.62	36.41±10.37
T_5	39.00±6.56	1.15±0.19	1.75±0.35	2.05±0.76	28.14±3.44
T_6	38.33±10.97	1.13±0.32	2.19±0.46	2.57±1.30	32.72±7.87
T_7	26.67±14.29	0.78±0.42	1.41±1.00	1.38±1.34	20.40±15.53
T_8	39.00±11.36	1.15±0.33	2.17±1.06	2.73±2.13	33.71±15.03
T_9	48.67±6.51	1.43±0.19	2.59±0.49	3.72±0.90	39.53±5.71
T_{10}	42.00±1.73	1.24±0.05	2.48±0.65	3.08±0.88	37.95±9.45
T_{11}	44.67±4.62	1.31±0.14	2.64±0.47	3.47±0.64	38.60±7.46
T_{12}	32.00±10.44	0.94±0.31	1.72±0.70	1.76±1.06	25.40±10.22
T_{13}	33.67±13.50	0.99±0.40	1.55±0.53	1.68±1.12	25.39±8.87
T_{14}	27.33±27.79	0.80±0.82	1.63±1.79	2.28±3.51	23.04±25.82
Mean	37.52±6.30	1.10±0.19	1.98±0.49	2.43±0.86	30.03±6.94

3. Results and discussion

The important germination parameters of *M. philippinensis* recorded maximum in treatment, soaking seeds in normal water for 12 hrs followed by soaking seeds in GA_3 solution @ 50 ppm for 60 min (T_9) for germination (48.67 %), Mean Daily Germination (1.43), Germination Value (3.72) and Germination Rate Index (39.53) whereas maximum Peak Value of germination (2.64) was observed in soaking seeds in normal water for 12 hrs followed by soaking seeds in GA_3 solution @ 100 ppm for 60 min (T_{11}). Normally pre-sowing seed treatments help to breakdown the physical and or chemical dormancy of seeds and to enhance the germination attributes. In the present trial, pre-sowing seed treatments may be able to break down the seed dormancy and ultimately enhancing the germination parameters. Among several pre-sowing treatments, seeds treated with normal water for 12 hrs followed by soaking seeds in GA_3 solution @ 50 ppm for 60 min was found to be good among other treatments and this treatment may be useful for enhancing the germination attributes of *M. philippinensis* in the nursery.

6.28/T_6-172

Growth performance and economics of different bamboo species at different spacing

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Keywords: Bamboo, spacing, growth, culm, economics

1. Introduction:

Bamboo is a fast growing perennial woody grass having clump forming in nature and long gestation period belonging to poaceae family. It comprises of 1662 species in 121 genera over the globe (Canavan *et al* 2017). Due to the clumping nature of bamboo, it needs to be focus on spacing between the plant to plant and plant to row. Spacing of bamboo increase competition which will directly affect overall growth performance, yield and economics. Hence, in this paper effect spatial arrangement of different bamboo species on growth performance and economics have been discussed.

2. Materials and Methods:

Current investigation evaluation consists of three different spacing at various site *viz*. 1.) 7.5 m x 7.5 m at Bambusetum, Singalkhanch, Tapi Forest Division, Vyara; 2.) 7.0 m x 7.0 m at Rambhas Farm, Waghai and 3.) 3.5 m x 3.5 m Bambusetum, BRC, CoF, NAU, Navsari. Also results of plantation done by farmers, different institutions, papers and theories provided by private companies, nurseries or firms were taken to compare for growth performance and economics at different spacing. All comparisons have been discussed in form of wider spacing (7.5 m x 7.5 m, 7 m x 7 m), optimum spacing (5 m x 4 m, 3.5 m x 3.5 m) and closer spacing (lesser than 3.5 m x 3.5 m). The data on thick wall bamboos *viz*., *Bambusa balcooa*, *B. vulgaris* (Green) and *B. bambos* were collected at above mentioned spacings. Outcome form the present investigation in context to spacing will be suggested for bamboo farming which provides better growth performance and economical returns.

3. Results and discussion

From, our results, comparisons and theories of private firms it is concluded that the optimum spacing leads to better growth performance with minimum competition and produce healthy culm which will directly influence the economics. Whereas, wider spacing accommodate a smaller number of plants which reduce overall yield per unit area while, closer spacing leads towards the competition between individuals which help to survival of the particular clump but with unhealthy clump which accounts for maximum number of clumps having lower biomass in same area of land. Bamboo culms obtained from optimum spacing are useful for almost all type of industries and utilization which provide multipurpose market and ensure higher economical returns. Bamboo culms from wider spacing are also good but due to accommodation of a smaller number of plants in per unit area it provides less economical return as compared to optimum spacing. In both spacing intercropping is also possible for initial years which add on to overall economical returns. However, closer spacing generally practiced to accommodate a greater number of plants per unit area but bamboo culms obtained from high density and ultra-high-density plantation are less in biomass which restrict it to certain market only which is also a part of further investigation.

Reference

Canavan S, Richardson DM, Visser V, Roux JJ Le, Maria S Vorontsova and Wilson JRR 2017. The global distribution of bamboos: assessing correlates of introduction and invasion. *Journal for Environmental and Evolutionary Plant Biology* **9**: 1-18.

6.29/T_6-173

Economics of Different Brinjal Varieties under Young Plantation of Gamhar (*Gmelina arborea* Roxb.) and Sole Cropping

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Keywords: Economics, *Gmelina arborea*, intercropping, eggplant, agroforestry

1. Introduction

Agroforestry, a discipline as old as civilization, is defined as the science of combining herbaceous and woody plants for the purpose of obtaining economic and ecological benefits. The combination of raising vegetables and trees together is crucial, profitable, and an additional source of income-generating among the different techniques used. In this regard, four different Brinjal varieties were evaluated for profitability under young plantation of Gamhar (*Gmelina arborea*) and sole cropping system.

2. Material and methods

The field investigation was carried out with an objective to check profitability of different varieties of brinjal under young plantation of Gamhar (*G. arborea*) and sole cropping at Instructional Farm, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, during summer 2022. In this experiment, four varieties of Brinjal *viz*., V_1: GNRB – 1, V_2: Swarna Mani, V_3: Surti Ravaiya, V_4: GAOB – 2 with RDF (100:50:50 NPK/ ha) were grown in open condition and under young planation of Gamhar (*G. arborea*) with three repetitions in Factorial Completely Randomized Design. Economics of different Brinjal varieties was calculated at the end of experiment based on cost of cultivation and produced yield.

3. Results and discussion

The data regarding net realization and benefit cost ratio of sole growing condition and Brinjal under young plantation of Gamhar are presented in Table – 1. In case of two growing conditions, maximum net realization and benefit cost ratio (BCR) were noted in sole cropping. Slight reduction in net realization and BCR was registered in young planation of Gamhar (*G. arborea* Roxb.).

Table 1. Economics of brinjal crop variety under *G. arborea* and sole cropping system

Treatment	Yield (kg/ ha)	Fixed cost (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Benefit to cost ratio
G_1: Sole growing condition					
V_1: GNRB – 1	48353.91	119347	580246.9	460899.9	3.86
V_2: Swarna Mani	47263.37	119347	567160.4	447813.4	3.75
V_3: Surti Ravaiya	24084.36	119347	289012.3	169665.3	1.42
V_4: GAOB – 2	29230.45	119347	350765.4	231418.4	1.94
G_2: Under Gamhar (*G. arborea*)					
V_1: GNRB - 1	38477.37	119347	461728.4	342381.4	2.87
V_2: Swarna Mani	40061.73	119347	480740.8	361393.8	3.03
V_3: Surti Ravaiya	17386.83	119347	208642	89294.96	0.75
V_4: GAOB - 2	21080.25	119347	252963	133616	1.12

***** Selling price of brinjal (12 ₹/kg)

Moreover, among four varieties of Brinjal, variety V_1: GNRB – 1 gave highest net realization (₹ 4,60,899.90) and BCR (3.86) in sole cropping. In case of young plantation of Gamhar (*G. arborea* Roxb.) variety V_2: Swarna Mani gave maximum net realization (₹ 3,61,393.80) and BCR (3.03). Although the economic parameters of *G. arborea* Roxb. is not fully assessed due to the newly established plantation and the growth of tree is not at market suppliable size yet looking at the faster rate of growth and demand of timber at several industries as well as production of vegetables with no extreme loss in terms of production and quality it could be said that the Gamhar - Brinjal based agroforestry system will surpass the economic feasibility of sole plantation of either Brinjal or Gamhar. The similar results are obtained earlier by Desai et al (2020) in babchi – sapota - jatropha based agroforestry system and Bony et al (2021) in lemon based agroforestry system.

References

Bony ZF, Rahman MA, Riyadh ZA, Saha SR and Zakaria M 2021. Productivity and profitability assessment of Lemon Based Agroforestry systems in Bangladesh. *Asian Research Journal of Agriculture* **14**(2): 42-49.

Desai MK, Dobriyal MJ, Tandel MB and Patel SM 2020. Performance and economics of medicinal crop (*Psoralea corylifolia* L.) under sapota-jatropha based horti-silviculture system. *Indian J. of Agroforestry* **22**(2): 80-85.

6.30/T_6-178

Novel Propagation of Fruit species through Mini-Cuttings and Leaves

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Keywords*:* Clonal technology, genotypes, mini-cutting, propagation

1. Introduction

The clonal technology has been emerging as a great attraction and alternate to traditional seed based propagation technology. Mini-cutting is one of the vegetative propagation methods where a shoot (2-7 cm) is used as propagating material. Vegetative propagation through leaves is also gaining more attraction (Thakur et al 2021). The main objective of study is to standardize mini-cutting and leaf propagation in four fruit species.

2. Material and methods

Mini-cuttings and leaves of 4 species such as *Anonona muricata*, *Annona squamosa, Garcinia morella* and *Morinda citrifolia* were planted in zip-lock covers with coir pith as rooting media inside the poly house. Three treatments such as Control, 1000ppm of IBA and 1000ppm of Coumarin was given. The experiment was conducted in two seasons (spring and rainy). Observations such as survival per cent, rooting per cent, mean root length and mean number of roots was recorded after 8 weeks of planting.

3. Results and discussion

Mini-cuttings of four species remained green in both spring and rainy season by end of 8thweek, but *Anonona muricata* and *Annona squamosa* leaves showed drying in spring.The survival per cent of all the four species was seen highest in rainy season than spring season. Three species except *Garcinia morella* showed rooting through mini-cutting. *Morinda citrifolia* is the only species which showed rooting through leaves. Treatment with 1000 ppm of IBA and coumarin was effective than control. Similar findings were seen where mini-cuttings treated with IBA had maximum rooting along with increased survival per cent and number of primary roots (Packialakshmi and Sudhagar 2019). This shows that it is possible to propagate genotypes with superior characteristics through mini-cutting with a greater number of seedlings per source.

Table 1. Influence of different treatments and seasons on mean number of roots and mean length of roots in *Morinda citrifolia* adopting leaf propagation and mini-cutting propagation (the values are Mean ± SD)

A. Leaf propagation

Sl. No.	Treatment	Mean number of roots		Mean root length (cm)	
		Spring	Rainy	Spring	Rainy
1	Control (T_1)	5.42 ± 0.52	2.63 ± 0.35	27.77 ± 0.21	14.50 ± 0.20
2	IBA 1000 ppm (T_2)	4.08 ± 0.14	2.97 ± 0.35	31.83 ± 1.26	15.13 ± 0.15
3	Coumarin 1000 ppm (T_3)	3.40 ± 0.35	1.80 ± 0.20	30.97 ± 0.45	23.60 ± 0.10
	SEm ±	0.21	0.23	0.45	0.09
	CD @ 1 %	0.75	0.80	1.59	0.32
	P value	<0.01	<0.01	<0.01	<0.01

B. Mini-cutting propagation

Sl. No.	Treatment	Mean number of roots		Mean root length (cm)	
		Spring	Rainy	Spring	Rainy
1	Control (T_1)	2.87 ± 0.23	13.60 ± 0.74	6.83 ± 0.21	11.03 ± 0.15
2	IBA 1000 ppm (T_2)	4.87 ± 0.23	7.08 ± 0.25	6.33 ± 0.15	11.47 ± 0.45
3	Coumarin 1000 ppm (T_3)	6.17 ± 1.04	3.53 ± 0.31	6.77 ± 0.25	19.53 ± 0.76
	SEm ±	0.36	0.28	0.12	0.30
	CD @ 1 %	1.28	0.98	N/S	1.05
	P value	<0.01	<0.01	0.05	<0.01

References

Packialakshmi M and Sudhagar RJ 2019. Standardization of rooting hormone in mini clonal technology of *Tectona grandis* Linn. *International Journal of Chemical Studies* **7**(3): 4398-4401.

Thakur NS, Hegde HT, Chauhan RS, Gunaga RP and Bhuva DC 2021. Root sucker technique for successful clonal multiplication of *Melia dubia* Cav. without sacrifice of mother tree. *Current Science* **121**(9): 1235-1237.

6.31/T_6-180

Germination Pattern of some Important Lesser Known and Threatened Tree Species: Nursery Prospective

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Keywords: Threatened species, germination, seed treatment

1. Introduction

Forest trees have vital role in mitigating climate change. Restoration and massive plantation of forest tree species are considered for improve the green cover of the country. Proposing lesser known tree and threatened plant species into such large-scale plantation programme help in conservation and management of such species out side the forests. Therefore, understanding seed biology and nursery technique provide a good plat form for production of quality seedlings in large quantity. In fact, preliminary information on seed traits, germination and seedling growth is poorly understood among LKTs and Threatened species. To fulfill some of these gaps, studies are being carried out in the research project at Navsari Agricultural University, Navsari, Gujarat, India. This paper provides information about germination techniques in some of these LKTs.

2. Material and methods

The present study consists of six LKT species *viz., Semecarpus anacardium, Pterocarpus marsupium, Dalbergia lanceolaria, Bauhinia malabarica, Miliusa tomentosa* and *Mallotus philippinensis.* Good fruits/seeds were collected from healthy trees and they were exposed to different pre-sowing treatments in the nursery. For germination, growing media was used and standard nursery procedure was followed. Daily germination count was made and germination percentage was worked out. Based on several pre-sowing treatments worked out among six species, the best pre-treatments are elaborated in the result.

3. Results and discussion

Studies shows that different pre-sowing treatments enhanced the seed germination over control. In *S. anacardium*, soaking seeds in conc. H_2SO_4 for 15 min followed by soaking seeds in normal water for 24 hrs resulted in 6.33 per cent improvement over control.

Table 1. Germination status of six lesser known and threatened tree species

Sr. No.	Tree Name	Best Treatment	Germination achieved (%)	Per cent improvement over control
1	*S. anacardium*	Soaking seeds in conc. H_2SO_4 for 15 min. followed by dipping in normal water for 24 hrs	19.67	6.33
2	*P. marsupium*	Soaking seeds in GA_3 @750 ppm for 12 hrs	66.33	36.33
3	*D. lanceolaria*	Soaking seed in cowdung slurry for 48 hrs	77.33	30.67
4	*B. malabarica*	Soaking seeds in conc. H_2SO_4 for 60 minutes	75.25	71.25
5	*M. tomentosa*	Soaking seeds in normal water for 24 hrs	56.33	17.33
6	*M. philippinensis*	Soaking seeds in normal water for 12 hrs, followed by dipping in GA_3 @ 50 ppm solution for 60 min	48.67	19.67

Whereas in *P. marsupium,* soaking seeds in GA_3 @750 ppm for 12 hrs resulted in 36.33 per cent improvement over control. Similarly, for *D. lanceolaria,* soaking seed in cowdung slurry for 48 hrs resulted in 77.33 per cent germination. In the case of *B. malabarica*, 75.25 per cent germination was recorded when seeds soaked in conc. H_2SO_4 for 60 minutes. Seeds of *M. tomentosa* soaked in normal water for 24 hrs resulted in 17.33 per cent improvement in germination over control. Similarly, *M. philippinensis* seeds exposed to soaking treatment in normal water for 12 hrs, followed dipping in GA_3 @ 50 ppm solution for 60 min provided 19.67 per cent germination over control. This shows that common pre-sowing treatment is found to be not suitable for seeds of all the species. Some seeds showed good result in physical treatment, while other few species resulted higher germination when seeds exposed to chemical treatments. Inference also shows that there is a scope for further improvement of seed germination in these species. Different pre-sowing seed treatments worked out for six LKTs shows that seed quality, structure and its biology play vital role in enhancing seed germination. The present study provides suitable pre-sowing treatment for enhancing seed germination in six studied species and they may be used for large scale seedling production in the nursery. Furthermore, this piece of information certainly helps the researcher for species conservation as well as restoration work.

6.32/T_6-191

Effect of Potting Mixture on Seedling Germination and Vigour of *Terminalia bellirica*

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Keywords: *Terminalia bellirica,* media, germination, growth, biomass, seedling

1. Introduction

Terminalia bellirica is commonly known as a Baheda. It is large deciduous tree native to India and about 100 species are distributed throughout the world. It is found commonly in plains and lower hills of Southeast Asia. In India it is abundantly found in Madhya Pradesh, Uttar Pradesh, Punjab and Maharashtra. It is a one of the India's most important multipurpose tree species. It is can be found throughout India. It is a member of the 'Combretaceae' family.

2. Material and methods

The present investigation undertaken during the year 2021-2022 at the College Nursery, College of Forestry, Navsari Agricultural University, Navsari, Gujarat, India. The experiment was laid out in Completely Randomized Design (CRD) comprising of five treatments T_1- Soil, T_2- Soil: Sand (1:1), T_3 – Soil: Sand: FYM (2:1:1), T_4 – Soil: Sand: Vermicompost (2:1:1), T_5 – Soil: Vermicompost: FYM (2:1:1) and it was repeated four times. Polythene bagof 6 x 8 inch was used, in which 10 seedlings per repetition per treatment were taken for study. Observation on effects of potting mixture on seeding height, collar diameter, number of leaves per plant, root length, fresh weight of shoot and root, dry weight of shoot and root was recorded after three month of seed sowing.

3. Results and discussion

Earlier germination (31.77 days) was recorded in treatment T_4 which was combination of treatments Soil: Sand:Vermicompost (2:1:1). Effects of potting mixture on seeding height, collar diameter, number of leaves per plant, root length, fresh weight of shoot and root, dry weight of shoot and root was found significant. Significantly maximum seeding height, collar diameter, number of leaves per plant, root length, fresh weight of shoot and root, dry weight of shoot and root were registered in treatment T_4 (Soil: Sand: Vermicompost) in 2:1:1 ratio. The next best treatment in relation to response was T_3 – Soil: Sand: FYM (2:1:1). Moreover, treatment T_1- Soil alone proved to be poorest treatment among all treatments with respect to germination, growth and biomass parameters.

Table 1. Effect of different growing media on germination, growth and biomass of *T. bellirica*

Treatment	Germination starting days	Seedling height (cm)	No. of leaves per plant	Collar diameter (mm)	Root length (cm)	Fresh weight of Shoot (g)	Fresh weight of root (g)	Dry weight of shoot (g)	Dry weight of root (g)
T_1	45.35	13.07	7.93	1.41	15.60	12.36	10.47	3.49	1.19
T_2	32.67	16.46	8.72	2.24	19.16	12.90	10.90	3.51	1.40
T_3	39.87	19.06	9.52	2.49	20.69	14.82	11.13	3.80	1.46
T_4	31.77	20.42	13.41	3.65	27.29	17.18	12.67	4.59	2.72
T_5	40.20	17.83	9.00	2.74	17.29	13.52	11.00	3.84	2.23
S.Em±	2.06	0.97	0.75	0.20	1.71	1.34	0.52	0.51	0.35
CD@ 5%	6.28	2.97	2.28	0.62	5.21	4.01	1.59	1.54	1.01
CV%	10.88	11.26	15.43	16.33	17.12	16.89	27.39	31.24	27.98

T_1- Soil, T_2- Soil:Sand (1:1), T_3 – Soil: Sand : FYM (2:1:1), T_4 – Soil: Sand : Vermicompost (2:1:1), T_5 – Soil: Vermicompost : FYM (2:1:1)

6.33/T_6-192

Volume, Biomass and Carbon content of Agroforestry Systems of Chikhli, South Gujarat, India

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Keywords: Carbon sequestration, agroforestry, volume, biomass

1. Introduction

AF systems provide higher income, multiple produces and environmental security along with wood and Non-wood forest produces among the farmers; moreover, tree and shrub species components help in sequestering more carbon. Therefore, in the era of climate change, conversion of monocropping into Agroforestry practices provide varieties of benefits to the grower and also help in maintaining local environment. In Gujarat, many farming communities have already started Agroforestry practices with varieties of tree as main component and agricultural crops, vegetables, medicinal, aromatic and spice plants, flowering plants as intercrops. In order to assess the tree components in terms of its growth, biomass, carbon contents in the different agroforestry systems, a survey was undertaken in different villages of Chikhli taluka, Navsari district of South Gujarat and prevailing agroforestry systems were documented and tree growth parameters were recorded for estimating biomass and carbon content.

2. Material and methods

In the present study, total five different villages of Chikhli taluka were selected during 2021. Various crop/tree components growing in the 10 different farms (small land holdings) were recorded. Tree biometric parameters such as height, DBH, mid diameter and crown characteristics were recorded. Further, tree volume, biomass and carbon content of tree components of selected AF Systems were estimated following standard formula.

3. Results and discussion

In the present study total seven crops *viz.*, Rice (*Oryza sativa* L.), Sugarcane (*Saccharum officinarum* L.), Turmeric (*Curcuma longa* L.), Yam (*Dioscorea alata* L.), Elephant fruit yam (*Amorphophallus paeoniifolius* L.), Taro (*Colocasia esculenta* L.), Okra (*Abelmoschus esculentus* L.Moench) and three tree species *viz.*, Teak (*Tectona grandis* L. f.), Mango (*Mangifera indica* L.), Sapota (*Manilcara zapota* (L). P. Royen) were recorded among 10 different AF systems studied during June to Sept. 2021.

Table 1. Tree volume, biomass and carbon yield in different AF systems

Sr. no.	AF System	Numbers of trees in AF system	Approximate farm area (m^2)	Volume (m^3) Based on total trees	Biomass per hectare (ton)	Carbon yield per hectare (ton)
1	Teak + Mango + Rice	56	3456	4.88	8.78	3.93
2	Teak + Sugarcane	16	1360	6.11	27.91	12.50
3	Teak + Mango + Turmeric + Yam	32	1762	4.91	16.23	7.23
4	Mango + Turmeric	13	1320	2.34	9.16	4.00
5	Mango + Teak + Sugarcane	29	2784	13.82	25.20	11.01
6	Mango + Elephant fruit yam	15	2044	1.19	2.81	1.23
7	Mango + Taro	10	1650	1.10	3.20	1.40
8	Mango + Okra	10	658	0.65	4.77	2.08
9	Sapota +Elephant fruit yam	10	5791	1.04	0.95	0.42
10	Sapota + Turmeric	5	2184	0.38	0.92	0.41

Since south Gujarat is hub for horticultural crops, famers are growing mainly mango and sapota as prominent crop and in the available space, they use to grow different economical crops as intercrop based on the season. Biometric study shows that yield and biomass depend upon the number of trees present, age of the tree (DBH and Height) and other inter-cultural practices. Based on total number of trees available in the respective farm, tree volume, biomass and carbon content were estimated and presented in Table 1. Among 10 AF systems, Mango + Teak + Sugarcane AF system resulted in higher tree volume (13.82 m^3 total tree basis), where in the case of biomass and carbon content, highest recorded in Teak + Sugarcane (27.91 tons ha^{-1} and 12.50 tons ha^{-1} respectively) and they were lower in Sapota + Turmeric AF system (volume calculated on total tree basis = 0.38 m^3, biomass of 0.92 ton ha^{-1} and carbon yield of 0.41 ton ha^{-1}). Study shows that small farmers can derive minimum of 0.09 to 0.41 tons carbon ha^{-1} from AF systems.

6.34/T_6-193

***Germination Studies in Millettia ovalifolia* Kurz.**

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Keywords: *Millettia ovalifolia, germination, pre sowing treatment, media*

1. Introduction

Millettia ovalifolia Kurz. (Moulmein Rosewood; Family-Fabaceae) is a legume tree species native of the tropics and subtropics of Asia and Africa. This species is relatively rare than Karanj and is very similar looking in its morphology. Species is considered as one of the avenue trees and it has medicinal properties. This species is practiced in traditional medicine and used in wound healing treatment, sores, skin diseases, snake bite, muscle aches, pains, *etc*. There are few trees in Waghai botanical garden maintained by Gujarat Forest Department, Dangs, South Gujarat. The regeneration information of this species is scanty. Therefore, this study was undertaken with objective to know the influence of pre-sowing treatments and potting media on seed germination.

2. Material and methods

The present study was carried out in the forest nursery of FPU plot, College of Forestry, NAU, Navsari, Gujarat, India. The pre-sowing treatments *viz.,* T_1: Control (No treatment), T_2: Soaking seeds in normal water for 24 hours, T_3: Soaking seeds in normal water for 48 hours, T_4: Soaking seeds in cowdung slurry for 24 hours, T_5: Soaking seeds in cowdung slurry for 48 hours, T_6: Soaking seeds warm water for 1 hr were exposed to freshly collected seedlots. Further, all these six treatments were sown in two different germination media *viz.*, M_1: Sand and M_2: Soil. Germination count and initial seedling growth were recorded.

3. Results and discussion

Seeds collected from single tree of *Millettia ovalifolia* Kurz. exposed to different pre-sowing treatments showed that both germination media and pre-sowing treatments influences the seed germination and initial seedling growth. Among two germination media, maximum seed germination was recorded in Sand medium (M_1) than Soil medium (M_2) in all the pre-treatments.

Table 1. Influence of germination media and pre-sowing treatments on seed germination and seedling vigour of *M. ovalifolia*

Pre-sowing treatments	Germination (%)			Seedling Height (cm)			Basal Diameter (mm)		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
T_1	64.0	46.0	55.00	7.91	7.21	7.56	1.42	1.31	1.37
T_2	70.0	34.0	52.00	7.53	6.49	7.01	1.41	1.38	1.39
T_3	50.0	30.0	40.00	7.74	6.05	6.90	1.62	1.14	1.38
T_4	48.0	30.0	39.00	8.45	6.32	7.39	1.39	1.20	1.30
T_5	64.0	22.0	43.00	7.29	7.76	7.53	1.40	1.12	1.26
T_6	16.0	32.0	24.00	7.53	6.04	6.79	1.27	0.97	1.12
Mean	52.00	32.33	42.17	7.74	6.65	7.19	1.42	1.18	1.30

T1: Control (No treatment); T¬2: Soaking seeds in normal water for 24 hours; T¬3: Soaking seeds in normal water for 48 hours; T¬4: Soaking seeds in cow dung slurry for 24 hours; T¬5: Soaking seeds in cow dung slurry for 48 hours; T¬6: Soaking seeds warm water for 1 hr.

Considering pre-treatment (irrespective of germination media), the best seed treatment was T_1 (55%), followed by T_2 (52%) and it was the least in T_6 (24%). By comparing pre-sowing treatment with germination medium, soaking seeds in normal water for 24 hrs resulted in maximum germination in sand medium (T_2M_1=70%), followed by seeds with no treatment sown in sand medium (Control T_1M_1=64%) and soaking seeds in cowdung slurry for 48 hours (T_5M_1=64%) than rest of the treatments. This inference was also noticed in the early growth of 45 days old seedlings in different treatments. Maximum germination obtained in the control could be due to use of fresh seeds, which are collected from standing tree and sown within a week. Further, soaking in water for 24 hrs soften the seeds and helped in early and maximum germination (Gunaga et al., 2011). However, warm water reduces the germination, where it adversely effects the living tissue. Sand medium could provide more aeration that helped the seed to germinate early than soil medium.Study shows that both germination media and pre-sowing treatments influences the seed germination in *Millettia ovalifolia. Further*, soaking seeds in normal water for minimum duration of 24 hrs in sand medium could be used for large scale seedling production of *M. ovalifolia*.

Reference

Gunaga RP, Doddabasav and Vasudeva R 2011. Enhancement of seed germination through proper pre-sowing treatment in *Calophyllum inophyllum*. *Karnataka Journal of Agricultural Sciences* **24**(3): 413-414.

6.35/T_6-194

Vegetative Propagation of Indian Tulip Tree [*Thespesia populnea* (L.)] through cuttings

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Keywords: *Thespesia populnea*, vegetative propagation, rooting, hormone

1. Introduction

Coastal erosion is the process by which local sea level rise, strong wave action, and coastal flooding wear down or carry away rocks, soils, and/or sands along the coast. Indian Tulip trees are highly tolerant to drought, strong winds, salinity and waterlogging. Such characteristics make this species suitable for coastal erosion control. It is a valued multipurpose tree species suitable for planting outside forest areas (Warrier et al 2015). Plantation raised through seeds has high variability resulting in low yield (Mehfuza et al 2020). In order to increase the yield per unit area, clonal technology has to be developed in Indian tulip tree.

2. Material and methods

To study influence of various levels of growth hormones on rooting of cuttings of Indian Tulip Tree tender shoots were collected and treated with various growth hormones in different concentration and planted in vermiculite media.

3. Results and discussion

Experiment was laid out with 10 treatments of different concentration of IBA, NAA and IAA in comparison with control and 3 repetitions in Completely Randomized Design. Among various growth hormones T2 *i.e.,* @ 250 ppm took minimum days to sprout (9.76 days) and 50 per cent sprout (12.08 days). Whereas days to sprout (11.89 days) and 50 per cent sprout (14.93 days) were maximum in control treatment. The maximum value of length of new sprouted shoot (29.38 cm), survival per cent (92.22), fresh weight of shoot and plant (24.43, 24.57 g/plant), dry weight of shoot and plant (19.33, 19.43 g/plant). While in rooting parameters, root length (12.01 cm), root: shoot ratio on length and weight basis (0.51 and 0.0067, respectively) were higher in T10 *i.e.,* IAA @ 1000 ppm. Furthermore, lower values of above all parameters were recorded in Control.

References

Mehfuza MP, Tandel MB, Prajapati VM, Patel SM and Desai MK 2020. Influence of various levels of growth hormones on rooting of cuttings of casuarina (*Casuarina equisetifolia* L.). *International Journal of Chemical Studies* **8**(5): 2183-2186.

Warrier KC, Venkataramanan KS, Balasubramanian T, & Singh BG 2015 *Thespesia Populnea*: An Ideal Species for Trees Outside Forests Programme in *Advances in Tree Seed Science and Silviculture*, Institute of Forest Genetics and Tree Breeding (Indian Council of Forestry Research and Education) PB 1061, Coimbatore, India, 311p.

6.36/T_6-196

Development of Volumetric Equation for Quick Assessment of Standing Trees of *Casuarina* sp.

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Keywords: Volume, regression equation, *Casuarina* sp., farmers, wood merchants

1. Introduction

Casuarina sp. (Family: Casuarinaceae) are commercial multipurpose tree species and well suited for agroforestry systems as wind break/shelter belt, soil conservation and nitrogen fixing trees. Presently, fast growing genotypes, clones and hybrids of *Casuarina* are planted across the country. Farmers are much benefitted for higher yield, economic returns and environmental security. Due to its fast-growing nature and local demand for pole and pulpwood, Gujarat farmers are growing this plant in their farmlands. Further, local industries *viz.*, paper industries (for pulp wood) and construction industries (for pole) are procuring raw materials from farms and plantations. The present study focused towards development of volumetric equation for this species.

2. Material and methods

The present study was carried out in different parts of south Gujarat Heavy rainfall zone AES-III, India. In order to develop volumetric equation, Casuarina trees belonged to 12 different diameter classes from 10-15 cm (D_1) to 65-70 cm (D_{12}) were considered (Table 1) and various biometric parameters such as tree height (H), dimeter at breast height (DBH, D), Mid- diameter, Form Quotient [FQ=DBH/MD] and Volume [$V=\pi D^2/4 \times H \times FQ$] were recorded/estimated (Gunaga et al 2021). Trees located in the conventional plantations, coastal belt, avenue/road-side plantations, agroforestry landscapes were used. Using these data volumetric equation was developed using regression equation.

3. Results and discussion

In the present study, about 1300 trees belonged to different diameter classes *viz.*, D1: 10-15 cm, D2: 15-20 cm, D3: 20-25 cm, D4: 25-30 cm, D5: 30-35 cm, D6: 35-40 cm, D7: 40-45 cm, D8: 45-50 cm, D9: 50-55 cm, D10: 55-60 cm, D11: 60-65 cm and D12: 65-70 cm, were selected in different parts of south Gujarat. Among them, after deleting out-layers, 1108 trees were used for assessment. Data pertaining height, diameter and mid-diameter, form quotient and volume are given in Table 1. Result showed that there was a huge difference in terms of diameter, height and volume calculated from lower diameter to higher diameter classes; therefore, data were grouped into two sets, the first set includes D1 to D7 diameter classes and the second set includes D8 to D12 diameter classes. Regression equations developed using first data set was Volume (V_1) = 0.00005 x HD^2+ 0.0196 (R^2 = 0.919), while volume for second data set was V_2 = 0.00003 x HD^2 + 0.6874 (R^2 = 0.712). Here, 0.0196 and 0.6874 are constant values used in the equation. Therefore, farmers, foresters, wood merchants and wood industrial persons can use these volumetric equations for quick estimation of standing volume of *Casuarina* trees.

Reference

Gunaga RP, LK Behera, SK Sinha, AA Mehta, NS Thakur 2021. Development of local volume table for Saru (*Casuarina equisetifolia* L.). *In:* Report of Forestry sub-committee of NAU presented in 17th Combined Joint AGRESCO at SDAU, SK Nagar, Gujarat. Pp. 33-44.

Table 1: Biometric parameters of standing *Casuarina* trees across different diameter classes

Diameter classes		Sample size (N)	DBH (cm)	Mid-dia. (cm)	Height (m)	FQ	Volume (m^3)
D1: 10 to 15 cm	Min	173	10.25	5.40	8.40	0.09	0.01
	Max		15.00	14.90	27.30	1.05	0.39
	Mean		12.68	9.13	16.54	0.71	0.16
D2: 15 to 20 cm	Min	132	15.10	8.20	10.50	0.51	0.14
	Max		20.00	17.30	29.20	0.94	0.63
	Mean		17.69	12.25	20.39	0.69	0.35
D3: 20 to 25 cm	Min	169	20.05	10.30	13.70	0.47	0.28
	Max		25.00	20.80	30.80	0.95	1.18
	Mean		22.75	14.29	21.81	0.63	0.56
D4: 25 to 30 cm	Min	180	25.05	12.60	15.20	0.46	0.41
	Max		29.95	22.10	33.10	0.82	1.50
	Mean		27.44	16.21	23.74	0.59	0.84
D5: 30 to 35 cm	Min		30.10	13.10	17.20	0.42	0.64
	Max	144	34.95	28.50	40.50	0.88	2.93
	Mean		32.48	18.72	26.54	0.58	1.29
D6: 35 to 40 cm	Min		35.05	14.80	19.70	0.40	0.94
	Max	129	40.00	37.50	41.50	1.00	4.56
	Mean		37.53	22.03	29.49	0.59	1.95
D7: 40 to 45 cm	Min		40.10	15.80	18.30	0.37	0.97
	Max	73	45.00	36.60	41.30	0.85	4.10
	Mean		42.49	23.52	30.42	0.55	2.42
D8: 45 to 50 cm	Min		45.05	19.50	26.20	0.40	2.16
	Max	40	49.85	33.40	45.50	0.74	5.54
	Mean		47.35	25.31	33.71	0.53	3.20
D9: 50 to 55 cm	Min		50.60	20.60	26.30	0.39	2.23
	Max	27	54.95	36.70	43.30	0.67	6.80
	Mean		52.98	27.54	32.56	0.52	3.76
D10: 55 to 60 cm	Min		55.40	20.50	27.10	0.35	2.80
	Max	21	59.95	38.10	45.10	0.66	7.11
	Mean		57.63	28.40	34.33	0.49	4.45
D11: 60 to 65 cm	Min		60.30	20.70	27.40	0.34	2.88
	Max	11	64.75	35.40	43.30	0.56	7.65
	Mean		62.23	27.17	33.93	0.44	4.58
D12: 65 to 70 cm	Min	9	65.95	23.70	31.10	0.36	4.30
	Max		69.50	31.30	41.70	0.45	7.11
	Mean		67.79	27.97	36.66	0.41	5.48
		1108					

DBH=Diameter at breast height; FQ= Form Quotient = Form Quotient

6.37/T_6-198

Studies on effect of Paclobutrazol (PBZ) on Phenological Events of Wild Aromatic Pickle Mango *(Appemidi)*

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Keywords: Pickle mango, paclobutrazol, flowering, growth retardant

1. Introduction

Appemidi, as it is known in Kannada, literally means the raw, un-ripened mango. It is a distinct type of pickling mango which is exclusively collected from the wild and it is processed as a pickle. Paclobutrazol is a wide-ranging plant growth retardant which selectively controls vitality of trees without marked effect on the fruit size.

2. Material and methods

The present work is carried out in clonal bank of *Appemidi* plants which was established at the agricultural Research station (ARS) Malagi, Uttara Kannada district. Treatment of PBZ were as follows T1 = Control (No PBZ application), T2 = Spray with Paclobutrazol (1 % solution), T3 = Root pruning (making trench of 30 cm deep at 90 cm from the trunk) and spraying with Paclobutrazol (1 % solution). The application of PBZ was carried out during November month of 2021.

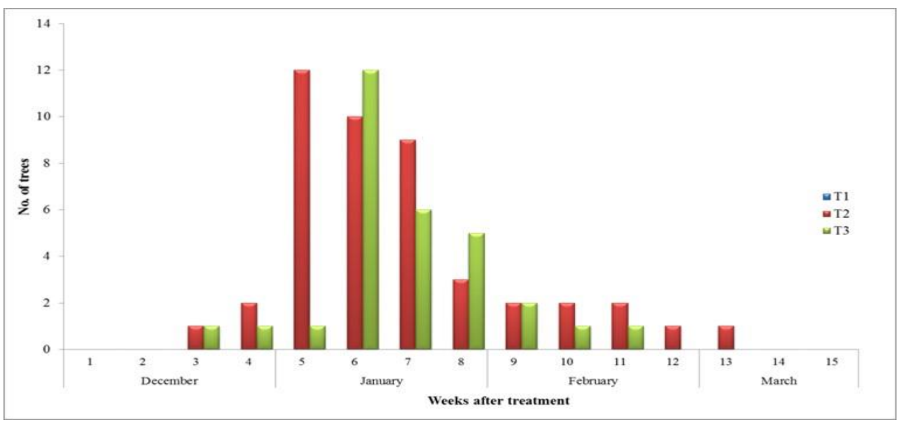

Fig. 1. Distribution of trees showing flowering initiation across time with respect to different treatments

3. Results and discussion

Maximum flowering was recorded at 5th week (*i.e.*, 1st week of January) after the application of treatments in T2, In both the treatments a gradual decrease in flowering was observed. The flowering period was extended up-to 13th week after the application of treatment (1st week of March). But in T3 treatment, trees terminated the flowering period at 11th week (3rd week of February) after application of growth regulator. Morales -Martinez et al (2020) who showed that the application PBZ + KNO_3 on seven years old mango cv. Tommy Atkins trees induced flowering in 16 days after the application of treatment where in control treatments the flowering initiated 107 days after the application of treatments.

Reference

Morales-Martinez M, Moscoso-Ramírez PA, Castelán-Estrada M and Contreras-Oliva A 2020. Effect of nitrates alone or with paclobutrazol on flowering induction and production in mango cv. Tommy Atkins. *Biotecnologia Vegetal* **22**(2): 20-27.

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info@gujcon.com | www.gujcon.com
Mo.: 98241 08779 | 92279 36720

LEEN INNOVATIONS PRIVATE LIMITED

"You name it, we have it"

- **SUPPLIER OF LAB CHEMICALS**
- **SYSTEM INTEGRATION**
- **SPECIAL PURPOSE MACHINE (SPM)**
- **INDUSTRIAL & LAB AUTOMATION**
- **HIGH PRECISION LAB EQUIPMENTS**

JK PAPER LTD

UNIT : CPM

Registered Office & Works:
P.O. Central Pulp Mills – 394 660
Fort Songadh, Dist: Tapi (Gujarat)
Contact no: 9328921151, 9328924027
Email: opshukla@cpmjk.jkmail.com

FACILITIES & PLANTATION PROGRAM OF JK PAPER LTD:

- Producing & providing quality planting material, site-specific and fast-growing clonal plants of Eucalyptus, Subabul and Casaurina species on minimum support price.
- Free of cost technical guidance to farmers throughout the year till harvesting.
- Buy-back guarantee for the plantation wood produced by farmers.
- Agreement with farmers on present Minimum Support Price (MSP) of Eucalyptus, Subabul and Casaurina wood.
- Free of cost Harvesting and Transportation of wood from farmers land to company by JK Paper Ltd, Unit-CPM, Fort Songadh-Tapi (Gujarat)
- Timely online payment of wood direct in farmers bank accounts through Internet banking.
- More focus on R & D for developing fast growing & high wood productive clones.
- R & D Tissue culture laboratory at JK Paper Ltd to produce highest productive Eucalyptus / Subabul / Casuarina clones.
- Clones matures for wood harvesting in 1.5 to 3 years.
- JK Paper Ltd takes initiative for carbon credit to farmers to raise their income from raised plantation.

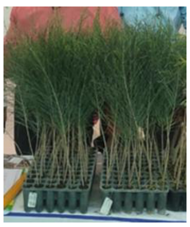
SOCIAL & ENVIRONMENTAL RESPONSIBILTIES:

- Scholarship to farmers children for Higher education.
- Wood harvesting from sustainable source like: FSC- CW and FSC- FM certified plantations under farm forestry plantation.
- Company is an ISO 9001: 2015, 14001: 2015 & ISO 45001:2018 certified by DNV and TQM activities.
- JK Paper Ltd is carbon positive by developing more plantation in catchment area.
- Sparsh Social foundation works for livelihood and social improvement of local community.


Clonal production and R&D Centre of JK Paper Ltd at Unit-CPM, Fort Songadh, District-Tapi (Gujarat)

Eucalyptus clonal plants

Subabul clonal plants



Casuarina clonal plants


Tissue culture plantlets of Eucalyptus & Subabul

Eucalyptus clonal plantation

Subabul clonal plantation

Casuarina clonal plantation

Agroforestry plantation