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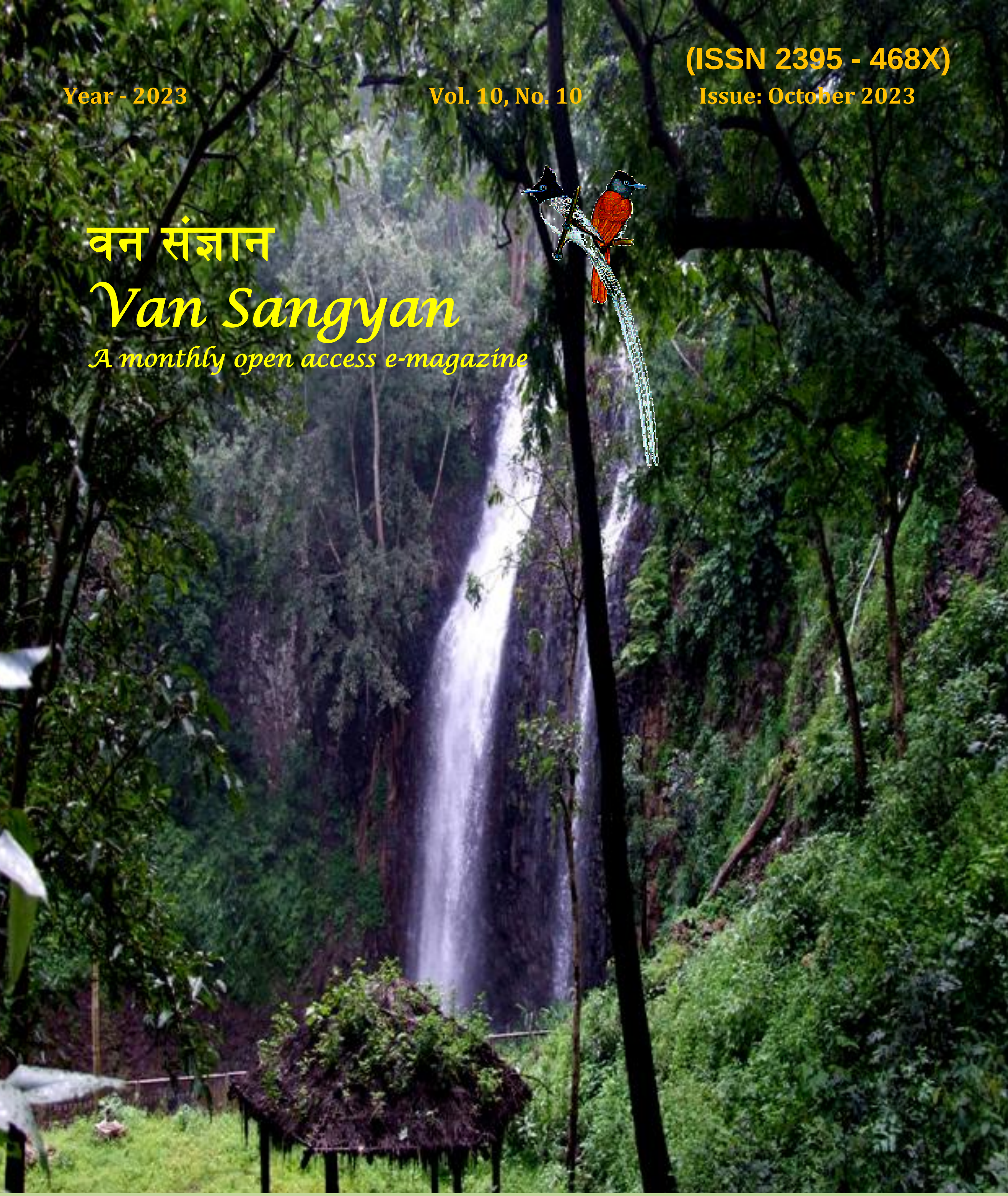

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Van Sangyan

Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

by e-mail to vansangyan_tfri@icfre.org

or, through post to The Editor, Van Sangyan,
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The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number.

TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

From the Editor's desk

At present, the urgency to safeguard natural forests and effectively manage plantations has never been greater. The demand for wood products is on the rise, but it is imperative to recognize that the preservation of existing forests is crucial for sustaining our quality of life. Consequently, there is a growing call for the application of precision management, a proven approach in agriculture, to be extended to forestry.

Precision forestry refers to an advanced method of managing forests with a high degree of accuracy and specificity. In this approach, various aspects of forests, such as characteristics, treatments, biodiversity preservation, and recreational opportunities, can be precisely determined at the level of individual trees, forest stands, or plots. Precision forestry relies on comprehensive and accurate information, including spatial details, to characterize the composition, structure, and productivity of a forest. This method is gaining prominence as it offers innovative solutions to existing challenges in forest management, contributing to improved decision-making processes and providing economic and ecological benefits.

In line with the above this issue of Van Sangyan contains an article on Precision forestry: Tools and technologies. There are also useful articles viz., Natural products derived from Roselle (Hibiscus sabdariffa) as a source of dye, Palash tree (Butea monosperma): Need to conserve in modern era, The cape floral kingdom: A jewel of biodiversity in South Africa's crown, Phytoconstituents and pharmacological activity of Himalayan pine species: A review, कृषिवानिकी के अन्तर्गत सर्पगन्धा की प्राकृतिक खेती, Tree and plants species for pollution management: A comprehensive review, An ideotype-a concept of model organism in forestry, Enhancing plant resilience in the face of drought stress: Strategies and approaches for mitigation and Insects associated with sal seeds.

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests. Van Sangyan welcomes articles, views and queries on various such issues in the field of forest science.

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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Precision forestry: Tools and technologies

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Introduction

Current wood production and increasing economic, environmental, and public demands from forests require new access to solutions and new technologies. Detailed data collected, analyzed, and stored is used for successful management—profitable management results from planning, organization, and control of all forest operations. The implementation of precision forestry reaches these claims. Precision forestry is a new direction for better forest management.

The concept emerged in the late 1990s in Washington State, USA; and in 2000 Precision Forestry Co-operative was formed (Schiess and Briggs, 2006). Initially, the first definition stated that Precision Forestry uses high-technology sensing and analytical tools to support site-specific economic and environmental decision-making for the forestry sector. Management principles of precision forestry are based on precision agriculture. Precision agriculture is an information-based, decision-making agricultural system designed to improve the farm process by precisely managing each step to ensure maximum agrarian production and continued sustainability of the natural resources (Rasher, 2001; Martinic *et al*., 2001). Precision agriculture is the management of agricultural inputs such as fertilizer and pesticides on a site-specific basis to decrease waste, boost revenues, and preserve environmental quality (Taylor *et al*., 2002). It uses a set of tools successfully introduced globally, and now they have been used in precision forestry.

Precision agriculture techniques are centered on a database of geospatial information, including soil fertility, crop yield, and in some cases, crop quality. Many harvesting machines now include yield monitors, which collect continuous data on the amount of crop collected as a function of field location. Field management units can be formed when yield maps are paired with soil fertility and type maps. Each management unit can have its fertilizer, herbicide, and pesticide rates. Using variable rate controller technology, the rates at which these inputs are applied can be changed as the applicator moves across the field. The capacity to tailor fertilizer and herbicide application rates to the demands of each management unit results in the more effective use of these inputs and, as a result, lower production costs and environmental implications.

What is precision forestry?

Many differences exist between the forest products and agricultural sectors; all the precision agriculture concepts do not directly apply to forest production systems. Moreover, different applications in forest management can be considered part of precision forestry. Precision forestry focuses on information and employs high-tech sensing and analytical tools to assist economic, environmental, and sustainable decisions. It provides highly reproducible measures, actions, and procedures for initiating, cultivating, and harvesting trees and protecting and improving the riparian zone, animal habitats, and other natural resources. It facilitates the exchange of vital information and connections among resource managers, the biological community, manufacturers, and public policy makers (Dyck, 2001).

A group of academics (Taylor *et al*., 2002) describe precision forestry as the planning and execution of site-specific forest management activities and operations to improve wood product quality and usage, minimize waste, boost revenues, and preserve environmental quality. Precision Forestry, in Ziesak's (2006) and Ackerman's (2006) opinion, uses high-technology sensing and analytical tools to support site-specific, economic, environmental, and sustainable decision-making for the forestry sector, thereby supporting the forestry value chain from bare land to the customer purchasing a sheet of paper or board. The following objectives can be met using geospatial-based tools and technology to plan, perform, and obtain site-specific forest management actions and operations.

- To improve the productivity of Forest
- For long-term planning
- To improve wood product quality and utilization, reduce waste, increase profits, and maintain environmental quality
- For quality assurance of timber management practices
- For global and crop inventory
- For the planning of the road network (hauling road, skid)
- For sustainable utilization of renewable resources
- To reduce adverse environmental consequences

The general field of precision forestry has been separated into two main categories:

Geospatial-information based forest management and planning

This area of precision forestry encompasses various activities that use geospatial information to assist in the site-specific management of forests and planning future operations. This contains many current management and planning activities since many industrial and private land owners use geospatial tools to manage their land bases. Traditional examples would include using Geographic Information System (GIS) to help develop management plans for forested areas; however, what makes these activities fit under precision forestry would be an emphasis on site-specific management. New examples of this type of precision forestry include the use of information technology to optimize the transportation of wood products from the forest to their most appropriate processing location. Advances in wireless communication are where much of this information can be shared from the harvesting machine directly to transportation dispatching services and manufacturing facilities.

Site-specific silvicultural operations

Geospatial technologies, like GPS and GIS, are used in site-specific silvicultural activities to enhance operational efficiency and lower the cost of the wood fibre. This consists in using much of the technology developed for precision agriculture. Control systems and field computers are available to provide real-time guidance information to machine operators to minimize over-application or skipped areas while assisting operators when navigating during operations. This technology is readily available and is currently being used in forest operations on a limited basis. New technology has been developed to provide automated machine guidance for agricultural tractors that could be adopted in certain forest operations. Combining the tree or log size data with GPS position will make the development of forest yield maps possible. The consequence of new technologies will assist with adopting them for site-specific silvicultural operations, and current forest industry trends of consolidation and workforce reduction will encourage more automation and data collection for the verification of services.

Precision silviculture

Precision silviculture is also a relatively new term gaining greater importance in modern tree farming. The term is like those frequently used in agricultural production circles, i.e., "precision agriculture" or "precision farming." Precision silviculture requires foresters to develop site-specific prescriptions for different sections of individual stands. Generally, precision silviculture applies a site-specific management concept. Many site-specific operations can be conducted cost-effectively without being automated. It should mean that the management process or operational activity is focused on making decisions for the smallest practical management unit area or number of management units within a given tract or management area. For example, this could determine how much fertilizer or herbicide is applied at a particular location on a tract. The magnitude of precision silviculture is the use of different tools and technologies for planning, conducting, and acquiring site-specific and condition-specific forest management activities and operations: to improve wood product quality and utilization, reduce waste, increase profits, and maintain environmental quality for quality assurance and compliance of timber management practices.

One of the critical components of raising plantations or tree farming is to maximize productivity by matching species and genotypes to site conditions. High productivity is an inherently aggressive growth characteristic of species and the development of optimum silvicultural practices to accelerate growth rate. The silvicultural practices such as site preparation, weeding, fertilizer application, intercultural operations, and protection would provide ideal plant growth conditions. The proper sequence of activities for plantation establishment and management is paramount in enhancing productivity.

Tools of precision forestry

New and sophisticated technologies are critical components of precision forestry. Precision technologies are instrumentation, mechanization, and information technologies that measure, record, process, analyze, manage, or actuate high-resolution multi-source data to allow information-based management practice or to promote scientific discovery. Precision forestry uses various tools and techniques, which can be categorized differently. Ziesak (2006) classifies methods into seven main activity fields:

- Surveying (terrestrial laser scanner, GPS, INS, and digital surveying equipment),
- Remote sensing (CIR, Airborne laser scanner),
- Contact-free materials testing and measuring computer tomography (CT), ultrasound, video, and laser scanner,
- Monitoring - radio frequency identification (RFID) and electronic nose (aroma) technology,
- Decision-making and harvest planning,
- GIS (Geographic Information System), DSS and visualization software
- Computer hardware.

Later, Kovacsova & Antalova (2010) categorized the tools into five categories, in which three tools were used for the collection of information and the other two for processing the information:

Tools for collection of information:

- Surveying technologies
- Airborne and satellite remote sensing technologies
- Real-time process control scanners

Tools for processing information:

- Geographic Information System (GIS)
- Decision support system

Surveying technologies

Currently, photogrammetric measurement methods with the support of terrestrial measurements using total stations, electronic tachymeters, and field mappers dominate forest mapping. Photogrammetric mapping obtains reliable geographic and dimensional information about physical objects and their environments through recording, measuring, and interpreting aerial photographic images. Photogrammetry is used in many fields, including topographic mapping. However, these approaches only offer information on some of the subtleties buried behind crops, where significant segmentation and opacity of terrain present numerous issues; this is why geodetic (terrestrial) methods are employed to supplement photogrammetric measuring methods. Surveying technologies such as Forest mapping technology using GNSS, Inertial navigation system (INS),and Terrestrial Laser scannerscan be used.

Airborne and satellite remote sensing technology

Remote sensing is the technique of gathering information about an object without coming into physical contact with the object. These technologies have significant advantages because they can quickly collect detailed data from a large area with varying conditions at repeated intervals. Downward or sideward-looking sensors installed on an airplane capture photos of the earth's surface in airborne remote sensing. Compared to satellite remote sensing, one advantage of airborne remote sensing is the capacity to provide pictures with extremely high spatial resolution (20 cm or less). The disadvantages are low coverage area and high cost per unit ground coverage area.

Mapping a large area using an airborne remote sensing system is not cost-effective. Airborne remote sensing missions are often carried out as one-time operations, whereas earth observation satellites offer the possibility of continuous monitoring of the earth.

In satellite remote sensing, sensors onboard satellites collect data about the earth's surface and the atmosphere below it and transmit the data/information to satellite ground stations for subsequent processing, analysis, interpretation, and applications. Remote sensing is a comparatively new field. It encompasses various subjects like natural sciences, environmental sciences, engineering and technology, social sciences, space science, and planning and management. Usually, airborne and satellite remote sensing technology includes: Light Detection and Ranging (LIDAR), Interferometric Synthetic Aperture Radar (IFSAR), and Global Positioning System (GPS)

Therefore, these systems are used for:

- Navigation on the ground and under the canopy
- Obtaining an accurate coordinate system of flying remote sensing technologies
- Navigation and monitoring the new forest and agriculture technologies
- Combination with handheld computers used for fieldwork

Real-time process control scanners

Precision forestry tools, as previously noted, deliver information in real-time. They have hardware and software devices that can be used directly in the forestry fieldwork (combination by GPS) or the wood processing industry (sawmill). This group can be divided into tree identification tools, wood material testing, and measurement. Such scanners includeRadio Frequency Identification (RFID), Ultrasound decay detectors, Computed tomography (CT), Automated Log Grading System, and Field Map (designed for computer-aided field data collection).

GIS (Geographic Information System)

GIS is a spatial information system comprising four essential GIS is a geographic information system comprising four fundamental components: hardware, software, data, and the user. It can export all types of data and graphs and give useful papers and plans to decision-makers by recording, storing, verifying, modifying, and analyzing terrain information connected to spatial and geographic distribution (Li *et al*., 2000). This system can handle a large volume of data.As a result, GIS may be utilized for forest applications (Wing & Bettinger, 2003). GIS works with various data types, including maps, photos, digital goods, GPS, text, and tabular data, all of which can come from various sources. Create big databases by acquiring and analyzing data in vector and raster formats.

Decision support systems (DSS)

DSS is an information system based on computers that assist companies or organizations in making decisions.DSS assists an organization's management, operations, and planning levels in making choices that may be volatile and difficult to predict in advance. Knowledge-based systems are examples of DSSs. A well-designed DSS is an interactive software-based system that assists decision-makers in compiling relevant information from raw data, papers, personal knowledge, or business models to identify, solve, and make judgments. The benefit of DSS is that it may be integrated with GIS, allowing us to enhance outcomes.

Technology landscape

Choudhry and O'Kelly (2018), from their work with forestry-management companies in all main forest regions, have identified 15 precision forestry technologies that show the most tremendous promise to transform operations and improve forest management:

Genetics and nurseries

- Advanced genetic improvement: gene mapping and marker-based breed selection to ensure plants have genetic profiles suited to the site and end-use.
- Automated nurseries: fully enclosed and controlled environments for raising seedlings under optimum plant health and growth conditions.

Forest management (silviculture)

- Site-specific management: prescriptions adapted to site needs, e.g., fertilization and drainage, often based on data from soil sensors.
- Pest and disease monitoring: digital monitoring of potential outbreaks, e.g., with UAVs, and coordinated responses to minimize damage to the forest.
- Mechanized silviculture: increased use of machinery to improve safety, labor productivity, and operations, e.g., via fertilization and weed control.
- Fire monitoring: digital monitoring of fires with satellites, e.g., to provide early warnings and coordinate fire-fighting.
- Water-management systems: central control of water infrastructure (e.g., flood gates) based on weather, soil moisture, canal water levels, and analytics.

Harvesting

- Digital inventory: measuring forest standing inventory—volume, species, and sometimes grade mix—by aerial remote sensing and in-forest devices.
- Mechanized harvesting: fully mechanized systems to improve safety, productivity, and process control.

Wood delivery

- Remote/automatic loading: loading cranes that can be operated remotely (e.g., from a truck cab or central office location) and eventually autonomously.
- Wood logistics optimization uses advanced software to control the central dispatch of trucks and other transport infrastructure.

Across the entire value chain

- Forestry-planning models: software to support forest management decisions, from strategic to tactical and operation
- Field support tools: mobile devices deployed in the forest, giving supervisors access to forest information systems and planning tools.
- E-dashboards: Visualize performance data using one central, standardized electronic repository.
- Advanced analytics: analysis of data to solve complex problems,

e.g., identifying constraints on tree growth at a micro level and determining effective interventions

Advantages and disadvantages of precision forestry

Advantages of precision forestry

Precision forestry and related tools benefit foresters, forest owners, wood processing enterprises, and others. Modern computer technologies enable immediate and direct contact between single forest activities. These technologies have considerable advantages in rapidly collecting extremely comprehensive data from a vast region with varied circumstances at repeated intervals. This helps forest enterprises and the wood processing sector to reduce costs while improving yield (Kovacsova, 2009).

According to Kinhal (2021) precision forestry has the following economic benefits:

- When compared to traditional approaches, the variable-rate application has reduced chemical consumption for herbicides and fertilizers by two-thirds.
- Mapping technology has grown more affordable and widely available.
- Rapid and regular reporting makes it simple to get examined digital data.
- Digital analysis and reporting eliminate mistakes during manual forest appraisal.
- The use of remote-sensed imaging makes forest appraisal less expensive and faster.
- Reduce illicit logging and damage by digitally monitoring tree-cover change.
- Monitoring woods with drones or satellites provides earlier warning of fires than direct observations, allowing for faster intervention.
- Other advantages of precision forestry include reduced - deforestation, illicit logging, forest management expenses, forest fires, and forest mapping costs.

Disadvantages of precision forestry

In precision forestry, instruments are rare in some forest companies. Individual precision forestry technologies must be coupled to gather more accurate information, including quantitative and qualitative characteristics of the forest resource. GIS, GPS, and remote sensing technologies are the most often utilized tool combinations since they provide enough resources for obtaining precise data and increased accuracy of information required for decision-making. Other tools have a limited range of use and are focused on a single sector of forestry management.

Precision forestry tools rely heavily on hardware and, in some instances, software. Because of the rising demand for hardware, purchase prices have risen, and tools are currently out of reach for all forest enterprises. Appropriate software analyzes all captured data from devices, and further information is obtained. It is critical in the design, implementation, and control of production processes and in assisting management by giving essential data on how to dispose of all relevant production elements (Katsch, 2006).

Conclusion

Precision forestry will enable future enterprises to become more economically viable while more economically viable while also meeting public and environmental objectives. This is critical for the long-term management of forests and renewable resources. Precision forestry may increase forest productivity, long-term planning, global and crop inventory, road network design (hauling road, skid trail), sustainable use of renewable resources, and decrease negative environmental impacts. At the same time, there are some challenges with information quality, namely issues with poor accuracy, low precision, incompleteness, and lacking relevance, all of which may be eliminated by combining and further developing precision forestry technologies.

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Natural products derived from Roselle (*Hibiscus sabdariffa)* as a source of dye

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Introduction

Hibiscus sabdariffa commonly named as "red sorrel" or "roselle" is a member of malvaceae family. It is a medicinal plant with a worldwide fame and has more than three hundred species which are distributed in tropical and subtropical regions around the world. Roselle can adapt to a variety of soil in a warmer and more humid climate. Roselle is rich in organic acids including citric, malic, tartaric and allo-hydroxycitric acids. The plant is also known for its Beta carotene, vitamin C, protein and total sugar. Roselle, having various medically important compounds called photochemical, is well known for its nutritional and medicinal properties. Many parts of Roselle including seeds, leaves, fruits and roots are used in various foods as well as in herbal medicine as a potential non-pharmacological treatment. Different extracts from Roselle plays a crucial role in treating different medical problems including many cardiovascular disorders, helmenthic disease and cancer. The plant also act as an anti oxidant and used in obesity management.

Taxonomic classification

Kingdom: Plantae – Plants
Subkingdom: Tracheobionta – Vascular plants
Superdivision: Spermatophyta – Seed plants
Division: Magnoliophyta – Flowering plants
Class: Magnoliopsida – Dicotyledons
Subclass: Dilleniidae
Order: Malvales
Family: Malvaceae – Wood-Sorrel family
Genus: Hibiscus
Species: *Hibiscus sabdariffa* L.

Origin

Its native distribution is uncertain; some believe that is from India or Saudi Arabia, while Murdock showed evidence that *Hibiscus sabdariffa* was domesticated by the black populations of western Sudan (Africa) sometime before 4000 BC. Nowadays, it is widely cultivated in both tropical and subtropical regions including India, Saudi Arabia, China, Malaysia, Indonesia, The Philippines, Vietnam, Sudan, Egypt, Nigeria and México.

Botany

Hibiscus sabdariffa is an annual, erect, bushy, herbaceous subshrub that can grow up to 2.4 m tall, with smooth or nearly smooth, cylindrical, typically red stems. The leaves are alternate, 7.5–12.5 cm long, green with reddish veins and long or short petioles. The leaves of young seedlings and upper leaves of older plants are simple; lower leaves are deeply 3 to 5 or even 7 lobed; the margins are toothed. Flowers, borne singly in the leaf axils, are up to 12.5 cm wide, yellow or buff with a rose or maroon eye, and turn pink as they wither at the end of the day. At this time, the typically red calyx, consisting of 5 large sepals with a collar (epicalyx) of 8 to 12 slim, pointed bracts (or bracteoles) around the base, begins to enlarge, becomes fleshy, crisp but juicy, 3.2–5.7 cm long and fully encloses the velvety capsule, 1.25–2 cm long, which is green when immature, 5-valved, with each valve containing 3 to 4 kidney-shaped, light-brown seeds, 3–5 mm long and minutely downy. The capsule turns brown and splits open when mature and dry. The calyx stems and leaves are acid and closely resemble the cranberry (***Vaccinium*** spp.) in flavour.

Cultivation

Hibiscus sabdariffa is easy to grow in most well drained soils but can tolerate poor soils. It grows best in areas with a well-distributed annual rainfall of 1,500 - 2,000 mm, though it can tolerate an annual rainfall of 640 - 4,290 mm, and an annual temperature in the range of 12.5 - 27.5°c. For best yields, roselle requires a permeable soil, a friable sandy loam with humus being preferable; however, it will adapt to a variety of soils. It will tolerate floods, heavy winds or stagnant water. Prefers a pH in the range of 4.5 to 8.0. Because of their deep root system, plants can tolerate some drought. Most of the time it grows as a supplement crop and it is susceptible to fungi, viral and bacterial attack and also to insects. A single plant produces about 1.5 kg of fruit, approximately 8 t/ha. Yields of leaves may be about 10 t/ha (EcoCrop, 2007).

Plant chemicals

Roselle is rich in anthocyanins and protocatechuic acid. The dried calyces contain the flavonoids gossypetine, hibiscetine and sabdaretine. The major pigment, formerly reported as hibiscine has been identified as daphniphylline. Small amounts of myrtillin (delphinidin 3-monoglucoside), chrysanthenin (cyanidin 3-monoglucoside) and delphinidin are also present. Roselle seeds are a good source of lipid-soluble antioxidants, particularly γ-tocopherol (Mohamed *et al*., 2012). The anthocyanin content of *H. sabdariffa* in five strains of the plant reportedly reached 1.7% to 2.5% of the dry weight during calyx growth. *H. sabdariffa* calyces contain high amounts of organic acids, iron, vitamin C (ascorbic acid), B_1 (thiamin), and B_2 (riboflavin), and a carotenoid (β-carotene), minerals especially potassium and magnesium.

Traditional uses

Different food products, fermented foods and beverages of *Hibiscus sabdariffa* are widely used in different countries. In Egypt, the fleshy calyces are used in making "cacody tea" and fermented drinks, while in Sudan and Nigeria; the calyces are boiled with sugar to produce a drink known as "Karkade" or "Zoborodo". In Mexico this drink is called Jamaica or "***agua de Jamaica***'" or "***té de Jamaica***". In Sudan, it is called as "tea Karkade." In Mali (Africa) it is called as "da Bilenni." Tea from the *Hibiscus sabdariffa* also called Sudan tea, sour tea which is prepared from ground dried calyces also have medicinal properties and is considered as herbal tea, and Roselle is also used as the main ingredient in many other tisanes. In the West Indies the calyces can also be used as colouring and flavouring ingredient in rum.

Fresh or dried calyces of H. sabdariffa are used in the preparation of herbal drinks, hot and cold beverages, fermented drinks, wine, jam, jellied confectionaries, ice cream, chocolates, flavouring agents, puddings and cakes. The calyx is rich in citric acid and pectin and is useful for making jams, jellies. On the other hand, the color extract from the dry calyces is rich in anthocyanin, amino acids, organic compounds, mineral salts, and source of vitamin C. Calyces extract is also a potential source of natural colorant to replace red synthetic coloring agents for carbonated soft drinks, jams, juices, jellies, sauces, chutneys, wines, preserves, and other acidic foods.

The seeds contain 17 to 20% edible fixed oil, which is similar in its properties to cottonseed oil. The seeds are eaten roasted or ground in meals, while the leaves and shoots are eaten raw or cooked, or as a sour-flavoured vegetable or condiment. In Sudan, the leaves are eaten green or dried, cooked with onions and groundnuts, while in Malaysia the cooked leaves are eaten as vegetables. In Africa, the seeds are roasted or ground into powder and used in meals, suh as oily soups and sauces. In China and West Africa, the seeds are also used for their oil. Another use for the seed is as a substitute for coffee.

Nutritional value

The nutritional composition of fresh calyx of Hibiscus sabdariffa varies between studies; this may be due to different varieties, genetic, environmental, ecology and harvest conditions of the plant. The calyx contains protein (1.9 g/100 g), fat (0.1 g/100 g), carbohydrates (12.3 g/100 g) and fibre (2.3 g/100 g). They are rich in vitamin C (14 mg /100 g), β-carotene 300 µg/100 g), calcium (1.72 mg/100 g) and iron (57 mg/100 g). The leaves contain protein (3.3 g/100 g), fat (0.3 g/100 g), carbohydrate (9.2 g/100 g), minerals (phosphorus (214 mg/100 g), iron (4.8 mg/100 g) thiamine (0.45 mg/100 g), β-carotene (4135 µg/100 g), riboflavin (0.45 mg/100 g) and ascorbic acid (54 mg/100 g) (Ismail, Ikram, & Nazri, 2008).The seeds contained crude fatty oil (21.85%), crude protein (27.78%), carbohydrate (21.25%), crude fibre (16.44%) and ash (6.2%). In terms of minerals, the most prevalent is potassium (1329 ± 1.47 mg/100 g), followed by sodium (659 ± 1.58 mg/100 g), calcium (647 ± 1.21 mg/100 g), phosphorus (510 ± 1.58 mg/100 g) and magnesium (442.8 ± 1.80 mg/100 g). The major saturated fatty acids identified in the seed oil are palmitic (20.84%) and stearic (5.88%) acids and the main unsaturated fatty acids are linoleic (39.31%) and oleic acid (32.06%) (Nzikou et al., 2011).

Natural products from Roselle

Roselle tea

Roselle tea is an herbal tea that has a distinct maroon color along with sweet and tart flavour. The tea is loaded with lot of essential nutrients and when consumed regularly have many health benefits *viz*., preventing hypertension, Diabetes, Heart diseases and cancer.

Roselle juice

A very refreshing, soothing and super healthy drink made of Roselle flower/calyx. Roselle is said to be rich in powerful antioxidants (flavonoids and anthocyanins) and vitamins A, B & C. The calyx is used for treating urinary tract infection, constipation, lowering blood pressure and cholesterol levels. Roselle drink can be had hot and chilled with lots of ice cubes. It can be made with fresh as well as dried ones.

Roselle jam and jelly

Rosella jam and jelly are made from calyces of roselle, and has a gorgeous, bold ruby red color. It's naturally packed with vitamin C and various antioxidants, which makes it healthy and delicious products.

Roselle seed oil

Roselle seed contains about 20% oil and is considered to have high nutritional value and health-promoting properties due to the presence of natural balance between saturated: mono unsaturated: poly unsaturated fatty acids. Functional lipid components that are likely present in roselle seed oil include phytosterols and tocopherols which have therapeutic functions in preventing cardiovascular disease and types of cancer.

Roselle Dye

Dried calyces

Extraction ↓

Aqueous / Solvent Dye Extract

Evaporation ↓

Concentrated Aqueous / Solvent Dye Extract

The calyces were washed thoroughly with water to remove dirt. They were dried under shade and grinded into very small units with the help of a grinding machine. The wastages are removed using a fine strainer, and finally, weight was taken. After drying, crushing, and removing wastages, the color component was extracted from the calyces in aqueous/solvent extraction process. The dye was extracted from the grinded roselle calyces by boiling it maintaining a substance and liquor ratio of 1:10 at temperature of 100˚C for 60 minutes in water bath. The hot dye solution was cooled down and the dye extract was eventually filtered carefully. When it is used for dyeing in textile industries/ food colourant, it gives different pink colour shade.

Conclusion

Roselle appears to be a good and promising source of water-soluble natural red pigments. In addition to being used as flavouring for sauces, jellies, marmalades, and soft beverages, Roselle has also been claimed to be used as a food colourant. Roselle has been used as a therapeutic plant for centuries. Traditionally, extracts treat toothaches, urinary tract infections, colds, and even hangovers. Several pharmacological and clinical studies suggest roselle can be a good source of natural color in the form of antioxidant, antimicrobial, anti hypertension, and many other properties like anti-inflammatory, hepatoprotective, and anti tumoral effects have been highlighted. There is a huge demand for commercial cultivation of roselle and quantification and purification of anthocyanins found in the calyces of Roselle. This will further help in generating entrepreneurship opportunities and upliftment of the socio-economic condition of the farming community.

Roselle plants and its calyx

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Palash tree (*Butea monosperma*): Need to conserve in modern era

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Introduction

"We are the same as plants, as trees, as other people, as the rain that falls. We consist of that which is around us; we are the same as everything." By Lord Gautam Buddha. *Butea monosperma*, also known as the Flame of the Forest or Bastard Teak, is a tree species deciduous tree that is native to the Indian subcontinent, Southeast Asia, and China. It belongs to the family Fabaceae and is known for its striking orange-red flowers that bloom during the spring season.

Distribution

The distribution of Palash tree in the world is mainly restricted to tropical and subtropical regions of Asia. In the word, it is found in India, Nepal, Sri Lanka, Bangladesh, Myanmar, Thailand, Cambodia, Vietnam, and Indonesia. In India, it is commonly found in the central and eastern regions, particularly in the states of, Rajasthan, Madhya Pradesh, Chhattisgarh, Jharkhand, Bihar, West Bengal, Odisha, and parts of Uttar Pradesh, Maharashtra, and Andhra Pradesh.It is widely cultivated in gardens, parks, and as an ornamental tree in various parts of the world. However, it is not found in the wild outside of its natural range.

Butea monosperma is found in both tropical and subtropical regions. It is hardy tree that can be tolerating range of climatic conditions but it prefers a hot and dry climate. The tree can grow in areas with an average annual rainfall of 500-1500 mm and temperatures ranging from 10-45°C. It can tolerate drought conditions and moderate frost (commonly found in areas with a frost-free period of at least 7-8 months) but it cannot survive in areas with heavy rainfall areas or water logging.

It can grow in a wide range of soil types, from sandy to clayey soils, but it prefers well-drained soils with a pH of 6.0-8.0.The tree can tolerate both acidic and alkaline soils, but it grows best in neutral to slightly alkaline soils. The soil should be rich in organic matter, with good water-holding capacity. Sandy loam, clay loam, and red laterite soil is considered suitable for the growth of *Butea monosperma***.**

History and significance

The Palash tree is an iconic tree species in India. Its bright orange-red flowers are a common sight during the spring season in many parts of the country. Here is a brief history of the Palash tree in India:

Ancient Indian literature

The Palash tree has been mentioned in ancient Indian literature, including the Vedas and the Puranas. It is believed to have been associated with the god of fire, Agni, and was considered sacred.

Traditional medicine

The Palash tree has been used in traditional medicine for its medicinal properties. Various parts of the tree, including the bark, leaves, and flowers, have been used to treat a range of ailments, including diarrhea, dysentery, and skin diseases.

Cultural significance

The Palash tree is an important part of Indian culture and is often associated with spring festivals like Holi and Vasant Panchami. Its flowers are used to make natural colours for Holi celebrations, and the tree is worshipped during Vasant Panchami.

Environmental importance

The Palash tree is an important species for the environment as it provides habitat and food for many species of birds and insects. It is also a nitrogen-fixing tree, which means it enriches the soil and promotes the growth of other plants.

Conservation efforts

Despite its cultural and environmental importance, the Palash tree is facing threats from deforestation and habitat destruction. Efforts are being made to conserve the species, including through the establishment of Palash tree plantations and the promotion of sustainable harvesting practices.

Uses

Construction

The wood of *Butea monosperma* is hard and durable, making it suitable for use in construction. It is use for making furniture, doors, windows, and flooring.

Fuel

Butea monosperma timber is a good source of fuelwood. The wood burns slowly and produces a lot of heat, making it ideal for cooking and heating.

Charcoal

The wood of *Butea monosperma* is also used for making charcoal. The charcoal is used in various industries such as metallurgy, chemical production, and for cooking.

Handicrafts

The wood is also used for making handicrafts such as toys, bowls, and decorative items. The wood is easy to carve and has a beautiful texture and color.

Traditional medicine

In Ayurveda, the traditional medicine system of India, various parts of the *Butea monosperma* tree, including the bark, leaves, and flowers, are used to treat various ailments such as inflammation, diarrhea, and skin diseases.

Gulal and natural dye preparation

Tree is consider sacred in Hinduism and is associated with the festival of Holi, during which the bright red fresh flowers are used to make a gulal and natural dye.

Ornamental purposes

The bright red flowers of the tree make it a popular ornamental tree in gardens and parks.

Environmental uses

The tree is used for soil conservation, reforestation, and as an avenue tree.

Overall, *Butea monosperma* holds ecological, cultural, and medicinal importance, making it a valuable species for biodiversity conservation, traditional practices, and sustainable resource utilization but *Butea monosperma* trees loss population day-by-day of in India due to several factors. These factors are given below with heads:

Deforestation

Widespread deforestation in India, primarily for agriculture, urbanization, and infrastructure development, has resulted in the loss of natural habitats for *Butea monosperma* trees. When forests are cleared, these trees are often removed, leading to a decline in their population.

Logging and illegal timber trade

Butea monosperma trees are valued for their timberthat used for preparation of furniture and other industries items. Illegal logging and the unregulated timber trade contribute to the loss of these trees. Unsustainable logging practices can significantly affect their populations.

Grazing and browsing by livestock

Butea monosperma trees are vulnerable to damage caused by livestock grazing and browsing. Overgrazing by cattle, goats, and other herbivores can inhibit the growth and regeneration of these trees, ultimately leading to a decline in their population.

Agricultural expansion

As agriculture expands to meet the growing demands of the population, *Butea monosperma* trees often face clearance to make way for crop cultivation. Agricultural practices such as shifting cultivation, monocropping, and excessive use of chemical fertilizers can also degrade the soil and negatively affect the growth of these trees.

Climate change

Climate change poses a threat to the survival of many plant species, including *Butea monosperma*. Changing rainfall patterns, increased temperatures, and extreme weather events like droughts and floods can affect the germination, growth, and reproductive processes of these trees, leading to population decline.

Lack of conservation efforts

Insufficient conservation measures and limited awareness about the ecological importance of *Butea monosperma* trees have contributed to their declining population. Limited protected areas and inadequate enforcement of existing regulations have failed to provide adequate protection for these trees.

Therefore, we have need to conserve *Butea monosperma* for biodiversity conservation, maintaining cultural and medicinal traditions, preventing soil erosion, mitigating climate change, providing aesthetic value, and promoting sustainable resource management. Protecting this species contributes to the overall well-being of ecosystems and human communities. It is important to protect the biodiversity of India through implement conservation strategies such as afforestation, sustainable logging practices, protected area establishment, and raising awareness among local communities to address the loss of *Butea monosperma* trees in India and promote their conservation.

 

Images: Flowering stage of *Butea monosperma* tree in Jodhpur, Rajasthan

The cape floral kingdom: A jewel of biodiversity in South Africa's crown

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Abstract

The Cape Floral Kingdom, near South Africa's south-western tip, is a biodiversity hotspot of exceptional significance. With three times the plant species of the Amazon rainforest and 70% found nowhere else, it's a botanical marvel. Fynbos dominates 80% of the region, thriving in its scorched landscape. Fires are vital for its survival, promoting growth and eliminating invasives. As a UNESCO site, it's the most diverse of threatened hotspots. Urbanization, invasives, fires, climate change, and agriculture pose threats. Conservation efforts aim to protect biodiversity and promote sustainability. Exploring reveals rare flowers and interconnected flora and fauna. Preserving this ecosystem is crucial for future generations. The Cape Floral Kingdom is a testament to nature's magnificence and the need for preservation.

Introduction

The Cape Floral Kingdom, located near South Africa's south-western tip, is a lush landscape teeming with extraordinary biodiversity. Stretching over a vast area nearly the size of Portugal, this region boasts the highest concentration of plant species on the planet, surpassing even the renowned Amazon rainforest. What sets the Cape Floral Kingdom apart is that 70% of its 9,600 plant species are found nowhere else on Earth. Despite its seemingly unremarkable appearance from a distance, the region known as fynbos covers 80% of the landscape and reveals a mesmerizing tapestry of diverse vegetation upon closer inspection.

The remarkable ecological significance

Recognizing its ecological significance, much of the Cape Floral Kingdom has been designated as a UNESCO World Heritage site since 2004. Although it is the smallest among the world's six floral kingdoms, it stands out as the most diverse among the 36 biologically rich and threatened "hotspots" identified by Conservation International. These hotspots represent a mere 2.4% of the Earth's land surface, yet they support more than half of the world's endemic plant species and a significant portion of endemic bird, mammal, reptile, and amphibian species.

The lush tapestry of fynbos

Fynbos, the dominant vegetation in the Cape Floral Kingdom, encompasses approximately 9,000 plant species. From low-lying shrubs and succulents to spiky reeds and flamboyant orchids, the fynbos offers an astonishing array of shapes, sizes, and colors. Four plant families, namely Protea, Erica, Restio, and Geophyte, play a prominent role in this ecosystem. The Protea genus, in particular, includes South Africa's national flower, the king protea. These plants have evolved to thrive in the nutrient-poor soil and harsh climate conditions of the Western Cape, with fire playing a crucial role in their survival.

Figure.1 Mountain Fynbos

Figure.2 Peninsula Shale Fynbos

The role of fire in the ecosystem

The Cape Floral Kingdom is a flammable ecosystem that depends on periodic fires to stimulate seed germination and control invasive species. While fires historically occurred by accident during dry, hot summers, contemporary conservation efforts involve the deliberate setting of prescribed fires within designated areas. These fires not only facilitate the regeneration of dormant buds but also enrich the soil with minerals through the resulting ash. By eliminating invasive species, fires ensure the availability of water and light for the emerging seedlings.

Threats to Cape Floral Kingdom

However, the Cape Floral Kingdom faces several threats to its delicate balance. Urbanization, the spread of alien plant species, irregular fires, global climate change, and new forms of agriculture pose significant challenges to its preservation. Cape Town's rapid population growth has strained the region's infrastructure and water resources. Invasive species, such as the Australian acacia and non-native pine and eucalyptus trees, outcompete native vegetation, including fynbos. Climate change has led to drier winters and increased the frequency and intensity of fires, potentially endangering the slow-growing fynbos. Furthermore, agricultural practices, such as grape cultivation for wine production, have resulted in the clearing of fynbos habitats.

Conservation efforts and initiatives

To safeguard the Cape Floral Kingdom, conservation-minded organizations and government initiatives have joined forces. Efforts are underway to remove invasive vegetation, prevent irresponsible development, and promote sustainable preservation practices. The Flower Valley Conservation Trust and the Department of Environmental Affairs' Working for Water initiative are actively involved in removing non-native plants and educating the community about conservation. The CAPE Programme, which aims to protect a significant portion of the fynbos biome, has already achieved substantial progress in safeguarding the region and has set a target of protecting up to 30% by 2028.

Sustainable use of resources

The sustainable use of fynbos resources has gained traction in recent years, with many local companies promoting products infused with fynbos. Fynbos teas and honeys, rich in vitamins, minerals, and antioxidants, have garnered attention for their health benefits. Cosmetics and perfumes incorporating fynbos essences offer unique and captivating scents, while fynbos-infused gins have become popular among enthusiasts. Encouraging the responsible and sustainable utilization of fynbos resources not only supports local economies but also raises awareness about the importance of preserving this delicate ecosystem.

Marveling at the small wonders

Beyond its grandeur, the Cape Floral Kingdom's smaller wonders also captivate nature lovers. Hidden within the fynbos are countless rare and exotic flowers, whose delicate beauty is a testament to the intricate web of life that thrives in this region. The Fynbos Trail, a popular hiking route, provides an immersive experience of the kingdom's enchanting landscapes, showcasing the year-round display of vibrant flowers and the interconnectedness of its flora and fauna.

Conclusion

In conclusion, the Cape Floral Kingdom stands as a testament to nature's awe-inspiring creativity and resilience. With its unparalleled plant diversity, the region has rightfully earned its place as a UNESCO World Heritage site and a biologically rich hotspot. However, the Cape Floral Kingdom faces various threats that necessitate conservation efforts to preserve this extraordinary ecosystem. By addressing issues such as invasive species, fires, urbanization, and climate change, while also promoting sustainable utilization of fynbos resources, we can ensure the survival of this botanical wonderland for generations to come. Exploring the Cape Floral Kingdom's hidden treasures reveals not only the beauty of its larger flora but also the intricate tapestry of its smaller wonders, inviting us to marvel at the interconnectedness of life on Earth.

Phytoconstituents and pharmacological activity of Himalayan pine species: A review

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Introduction

Throughout human history, medicinal plants have been used as a key source of medicines to treat diseases and preserve health. Medicinal plants are a natural source with relatively few side effects compared to chemically based drugs and because they are becoming more and more expensive, researchers from all over the world are concentrating on this field of study. Plant extracts are often used as sweeteners, coloring agents, and preservatives in many pharmaceutical formulations because they have medicinal properties. Medicinal plants are important in almost all the countries in the Asia and pacific region. More than 80 percent of the population in the developing countries of the region is believed to be dependent on medicinal plants for curing various diseases. Ayurvedic and pharmaceutical industries have been obtaining 95 per cent of raw material of medicinal plants from forest till date.

India has a rich diversity of medicinal as well as aromatic plants and holds a unique place in the world in the traditional system of medicine thus called medicinal Garden of the world. India is one of the twelve mega-biodiversity areas of the world with approximately 45000 plant species. Pinus is large and economically important genus of over 110 species worldwide[11]. The genus is divided into two subgenera: Strobus (Haploxylon, soft pines) and Pinus (Diploxylon, hard pines).

There are five species of pines which are indigenous to India viz. *P. roxburghii* (Chir pine), *P. wallichiana* (Blue pine), *P. gerardiana* (Chilgoza pine), *P. kesiya* (Khasi pine) and *P. merkussi* (Sumatran pine). Among all *P. roxburghii*, *P. wallichiana* and *P. gerardiana* are found in the Himalayas, whereas *P. kesiya* and *P.merkussi* are indigenous to Assam (India) and Burma. *P. roxburghii* (chir pine) is a tall tree with spreading crown grows at an altitude of 450-2400 m from Kashmir to Bhutan and Siwalik hills. *P. wallichiana* (blue pine) found at an altitude 2000-3500 m whereas *P. gerardiana*, commonly (Chilgoza pine) found at an altitude of 1600-3000m in district Kinnaur of Himachal Pradesh. Keeping in view the importance of medicinal plants, the present review was aimed to thoroughly analyze the potential of Pinus species and to explore the therapeutic significance of Pine species from Himalayas.

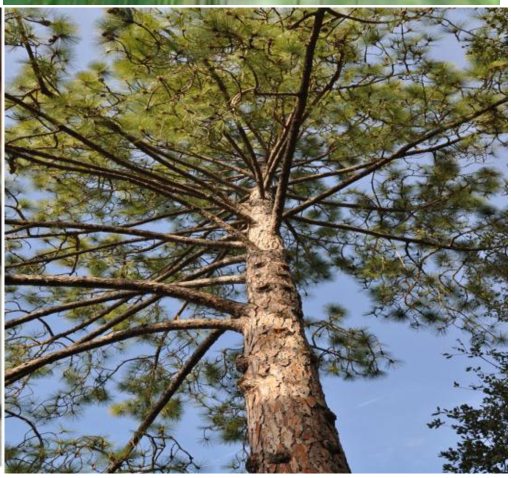
Pinus roxburghii

Habitat and morphology

Pinus roxburghii Sargent (Pinaceae) commonly known as chir pine, is a tall tree with a spreading crown found in the Himalayas from Kashmir to Bhutan, Afghanistan and in southern Indian hills at an altitude of 500 to 2,500 m above sea level and grows gregariously.

Pinus roxburghii is a large tree with spreading crown reaching 30-50 m with a trunk diameter of up to 2 m. It is a large tree with branches in more or less whorled, bark dark gray, often reddish, deeply fissured, rough, exfoliating in longitudinally elongated plates, leaves in clusters of three, 20-30 cm long, triquetrous, finely toothed, needle like, light green, persisting on an average for a year and a half; male flowers about 1.5 cm long, arranged in the form of cones, female cones, solitary or 2-5 together, ovoid, 10-20cm×7.5×13cm when ripe. The stem is tapped to produce a clear, translucent oleo-resin with a strong and bitter taste.



Taxonomy of *Pinus roxburghii*

Taxonomic classification	Synonym	Common names
Kingdom: Plantae Division: Pinophyta Class: Pinopsida Order: Pinales Family: Pinaceae Genus: *Pinus* Subgenus : Pines Species: *roxburghii*	*Pinus longifolia*	English: chir pine Hindi: Chil, Chir Sanskrit: Manojna Gujrati: Teliyodeodaro Bengali: Saralgachhai Malyalam: Salla, Charalam Tamil :Simaidevadari Telgu: Devadaru

Bioactive constituents in *Pinus roxburghii*

Part of plant	Bioactive constituents	References
Needle essential oil	α-Pinene (22.8%), camphene (0.4%), β-pinene(14.1), Δ3- carene (50.6%), α-phellandrene (0.1%),α-terpinene (0.4%), limonene (0.9%), β-phellandrene (0.7%), γ-terpinene (0.5%), p-cymene (tr), longipinene (0.2%), cyclosativene (tr), sativene (0.1%), longifolene (3.4%), β-caryophyllene (0.2%), α-terpeinyl acetate (0.3%), longicyclene (0.2%), terpinolene (3.8%), reported in resin. Zafar et al 2010 reported α-Pinene (29.3%), β-myrcene (1.1%), 3-carene (14.2%), terpinyl acetate (1.0%), α-terpineol (4.5%), borneol acetate (2.2%), α-longipinene (1.2%), caryophyllene (21.9%) and caryophyllene oxide (3.1%)	3
Wood essential oil	Caryophyllene (16.75), Thunbergol (16.29), 3 carene (14.95%), Cambrene (12.08%), alpha thujene (10.81%), terpinolen (7.17%), alpha pinene (4.8%), alpha caryophyllene (3.7%) , sabinene (3.79%), Verticol (1.84%), 4 terpineol (1.79%), myrcene (1.28%)	6
Bark essential oil	Alpha pinene (31.29%), 3 carene (28.05%), Cambrene (4.86%), Longifolene (4.42%), Thunbergol	6

	(4.11), beta pinene (2.99%), sylbestrene (2.4%), terpineol (2.05%), terpinolen (2.03), terpinyl acetate (1.56%), elemol (1.46%), Methyl dihydro abtate (1.3%), myrcene (1.36%), Bornyl acetate (1.1%), alpha cadinol (1.08%)	

Pharmacological activities of *Pinus roxburghii*

Part of *P. roxburghii*	Activity	Reference
Wood oil	Hepatoprotective	2
Resin	Antibacterial	2
Female cone	Antibacterial	2
Leaves (Needles)	Antidyslipidemic	1
	Antioxidant	1
	Wound healing	7
	Analgesic	5
	Antibacterial	2
	Anti-Inflammatory	5
	In-vitro cytotoxicity	13
Needle oil	Anti-fungal	13
Bark	Anticonvulsant	5
	In-vitro cytotoxicity	13
	Antibacterial	2
Cone oil	Anti-fungal	13

Pinus wallichiana

Habitat and morphology

Pinuswallichiana A.B. Jackson or the blue pine is one of the species of Pinus that is native to Himalayan ranges, Karakoram range and Hindu Kush Mountains. The extensive and luxuriant growth of this plant is found all along the Himalayan ranges starting from eastern Afghanistan, extending all the way through Pakistan, Indian, Nepal, Bhutan, Myanmar and China with an altitudinal range from 1800 meters to to 4300m.

Pinus wallichiana attains a height of more than 50 meters having a straight trunk and short down curved branches creating a dome like structure. When young, the bark of the trunk is smooth and resinous; but, as it ages, it becomes corky, grey, and has shallow fissures. Needles are 10 cm to 20 cm in length, bluish green in colour occurring in cluster of five per fascicle. Female cones are light brown at maturity and highly resinous. The male cones are ovoid or globose; short lived, comprising of scales or microsporophylls each bearing a pair of pollen sacs on the lower surface. Seeds are ovoid, 6-10 X 5-6 mm in dimension having membranous wings of 1.5 to 3 cm in dimension.

Taxonomy of *Pinus wallichiana*

Taxonomic classification	Synonym	Common names
Kingdom: Plantae Division: Pinophyta Class: Pinopsida Order: Pinales Family: Pinaceae Genus: *Pinus* Subgenus :Strobus Species: *Pinus wallichiana*	*Pinus excels* *Pinus griffithii* *Pinus chylla*	Botanical name:Pinus wallichiana English :Himalayan pine Hindi: Kail Kashmir Yiro, kail,kaiar Bhutan Tongschi Lamshing German :Tranenkiefer

Bioactive constituents in *Pinus wallichiana* A.B. Jacks

Plant Part	Chemical constituents	Reference
Needle essential oil	α-Pinene (25.2%), β – Pinene (46.8%), Myrcene (9.5%), α – Terpineol (2.3%), Caryophyllene Oxide (2.1%), Trans Caryophyllene (1.8%), Limonene (1.0%), α- Cadinol (0.9%), Camphene (0.9%), α-Terpinyl Acetate (0.8%), Delta3-Carene (0.8%), α-Bisabolol (0.6%), α- Humulene (0.5%), α-Phellandrene (0.4%), δ- Cadinene (0.4%), Transpinocarveol (0.4%), Geranyl acetate (0.1%)	19
Turpentine	α- Pinene (90.7%), Camphene (2.5%), β – Pinene/Sabinene/C11 (2.1%), Δ-3-Carene/myrcene	3

	(0.4%), α- Terpinene (0.1%), Limonene (0.5%), β-Phellandrene (0.1%), γ- Terpinene (Trace), p-Cymene (0.2%), Terpinolene (0.4%), Longipinene (0.3%), Cyclosativene (Trace), Longicyclene (Trace), Sativene (Trace), Longifolene (0.6%), β- Caryophyllene/ terpinen-4-ol (0.5%), Trans-β-Farnesene/αhumulene (0.1%), α- Terpineol/borneol (0.2%).	
Resein Acid	Pimaric Acid (0.7%), Levopimaric Acid/Palustric Acid (9.7%), Isopimaric Acid (23.2%), Lambertianic Acid (20.5%), Dehydroabietic Acid (1.7%), Abietic Acid (31.5%), Neoabietic Acid (4.8%).	3
Stem bark methanolic extract	Kampherol (2.300%), Rhamnetin (2.08 %), Myrcetin (3.0%), Isorhamnetin (2.005%), Quercetin (5.009)	9
Methanolic extract of needle	Isorhamnetin (2.857%), Quercetin (21.426%)	9

Pharmacological activities of Pinus wallichiana

Activity	Parts used	Reference
Antimicrobial activity	Needles	9
Insecticidal activity	Needles	9
Antioxidant	Bark	14
Anti inflammatory	Bark	14

Pinus gerardiana

Habitat and morphology

Pinus gerardiana is usually recognized as **"chilgoza or neoza pine"**. The distribution of *Pinusgerardiana*in the world is very scarce, restricted to mountain ranges of east area of India, Pakistan, Afghanistan, as well as dispersed areas of the Himalayan Hindu Kush. *P. gerardiana*, found at an altitude of 1600-3000m in district Kinnaur of Himachal Pradesh. *P. gerardiana* is known by "Champion of Rocky Mountains" and flourish in the tough circumstances in the interior Himalaya[15].

Pinus gerardiana is a small to medium-sized tree that grows to a height of 24 meters as well as 3.5 meters of girth found in the inner and valleys of the North-West Himalayas, from Garhwal to the west. The branches of the plant are compact, short, and horizontal, whereas the bark is skinny, glabrous, silver greyish, exfoliates in irregular thin flakes. Female cones are oblong or ovoid and have thick, woody scales, while male cones are long. Seeds are cylindrical, elongated, dark brown pointed at the tip. *P. gerardiana* found in India supplies eatable nuts, high amount of proteins, moisture, carbohydrates, fat, roughage as well as mineral content.

Taxonomy of *Pinus gerardiana*

Taxonomic classification	Synonym	Common names
Kingdom: Plantae Division: Pinophyta Class: Pinopsida Order: Pinales Family: Pinaceae Genus: *Pinus* Subgenus : Ducampopinus Species: *Pinus gerardiana*	*Pinus gerardii*	English : Chilgoza Pine Hindi: Chilgoza, Neoza Sanskrit: Dhanu,priyalam Gujrati name: Chaolli Bengali: Chirongi Malyalam: Mungaper Tamil:Sarra payer Telgu: Morrihettu

Phytochemical constituents

The nuts are considered to be rich source of various nutrients including proteins, carbohydrates, fibers, minerals besides its higher amount of oil. Its oil is of very good quality, free of cholesterol and a rich source of fatty acids. The seeds with edible kernels are obtained from ripe cones credited with carminative stimulant and expectorant properties. On pressing kernels yielded transparent clear oil having pale yellow.

Plant Part	Chemical constituents	Reference
Chilgoza nut oil	Stearic acid (0.3%), Linoleic acid (Omega-6) (51.3 %),	4,18

	Linolenic acid (Omega-3) (1.5%) Oelic acid (Omega-9) (39.7% Arachidic acid (2.1%) Palmitic acid (7.2%)	
Kernel	Moisture (7.5%), protein (15.9%), fat (49.9%), carbohydrates (21.6%), fibre (2.2), and mineral matter (2.9%)	4

Pharmacological activities of *Pinus gerardiana*

Activity	Parts used	Reference
Antioxidant assay	Chilgoza	15
Cardiovascular disorders and thromboembolism	Nuts oil	11
Antiinflamatory	Bark	15
Antimicrobial assay	Bark	15

Conclusion

This review reveals the presence of various phytochemical components and their pharmacological properties in *Pinus roxburghii*, *Pinus wallichiana*, and *Pinus gerardiana*. The significance of Himalayan Pine species as a valuable source of phytoconstituents with diverse chemical compositions such as terpenoids, flavonoids, phenolics, and essential oils, have been associated with numerous health benefits, including antioxidant, anti-inflammatory, antimicrobial, anticancer, and antidiabetic properties. The pharmacological activities discussed in this review strongly support the high therapeutic potential of these plants. However, to fully harness the medicinal properties of these pine species, further comprehensive studies, pharmacological investigations and extensive exploration are required. Public awareness is also essential to maximize the utilization of these medicinal properties. Industrial entrepreneurs should actively engage with innovative concepts and initiatives to best utilize the potential of these medicinal pine species. With these efforts, it is hopeful that herbal products will eventually compete with modern medicines, offering added advantages of enhanced safety and affordability.

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कृषिवानिकी के अन्तर्गत सर्पगन्धा की प्राकृतिक खेती

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प्रकृति ने अनेकों प्रकार की औषधीय प्रजातियों को हमारी धरती पर उत्पन्न किया है जिनका प्रयोग अनेकों प्रकार की बीमारियों में होता है। वर्तमान में औषधीय पौधों की मांग बढ़ने से आजकल औषधीय पौधों का कृषिकरण जरूरी है। इन प्रजातियों में सर्पगन्धा (राउलफिया सर्पेन्टिना) एक महत्वपूर्ण प्रजाति है।सर्पगन्धा को कृषिवानिकी पद्धति के अन्तर्गत भी उगाया जा सकता है जिसमें तेजी से बढ़ने वाले वृक्षों को अपनाकर अतिरिक्त लाभ लिया जा सकता है। कृषि वानिकी पद्धति में एक ही भूमि पर वृक्ष, फल वाले वृक्ष जैसे- नगदी फसल, औषधीय फसलें एवं वृक्ष, इमारती लकड़ी व आश्रय देने वाले वृक्षों के साथ कृषि फसलों, सब्जियों, दलहन, तिलहन की खेती किया जाता है। वृक्ष प्रजातियों को प्राथमिकता के आधार पर उगाने से ज्यादा लाभ प्राप्त होता हैं। कृषिवानिकी के अन्तर्गत पेड़ों की कतारों के बीच अंतर फसलों को उगाया जाता है।

कृषिवानिकी के तहत औषधीय और सुगंधित पौधों जैसे- सर्पगंधा, घृतकुमारी, सफेद मूसली, कालमेघ, लेमनग्रास, पालमारोजा आदि की जैविक खेती करके लाभकारी बनाया जा सकता है। वृक्षों में कृषिवानिकी के विभिन्न पद्धतियों के अन्तर्गत तीव्र गति से बढ़ने वाले वृक्ष जैसे- सागौन, पॉपुलर, सफेदा, बकैन, शीशम, बांस एवं नीम आदि वृक्षों को किसानों द्वारा विभिन्न शस्य जलवायु वाले क्षेत्रों में अपनाया जाता है। द्वीद्धलीय वृक्ष प्रजातियों को अपनाने से नाइट्रोजन का स्थिरीकरण भी खेतों में होता है।

औषधीय पौधों की अधिक आमदनी हेतु जैविक खाद जैसे-गोबर की सड़ी खाद,वमीकम्पोस्ट, हरी खाद आदि का प्रयोग प्रजाति की आवश्यकता के अनुसार किया जा सकता है। औषधीय एवं सुगंधित पौधों में जैविक खाद का उपयोग करना हमेशा बेहतर होता है।इस पद्धति के तहत किसान सर्पगन्धा जैसे महत्वपूर्ण औषधीय पौधे को सागौन, कैजुरिना (झाऊ) आदि पर आधारित खेती करके अच्छा लाभ अर्जित कर सकते हैं।

सागौन अपने उच्च लकड़ी मूल्यों और बाजार की उपलब्धता के कारण कृषिवानिकी में बहुतायत में किसानों द्वारा पूर्वी उत्तर प्रदेश में फसलों के साथ-2 मेड़ों पर उगाया जाता है जो देश में इमारती लकड़ी और ईंधन की लकड़ी की मांग को पूरा कर सकता है। सर्पगन्धा को सर्वोत्तम रूप से उच्च रक्तचाप के लिए भी जाना जाता है। सर्पगन्धा का उपयोग पेंचिस, दर्दनाक संक्रमण, आंतो में संक्रमण, गर्भाशय के संकुचन एवं पेट के बुखार आदि बीमारियों एवं स्वास्थ्यवर्धक दवा बनाने में उपयोगी है।

वर्तमान समय में सर्पगन्धा की जड़ों की व्यवसायियक आपूर्ति ज्यादातर उत्तर प्रदेश, बिहार, उड़ीसा, पश्चिम बंगाल, असम,

आन्ध्रप्रदेश, तामिलनाडु, केरल, कर्नाटक और महाराष्ट्र से होती है। आयुर्वेदिक तथा यूनानी चिकित्सा के अन्तर्गत इसकी जडों का प्रयोग विभिन्न प्रकार की बीमारियों के उपचार में होता है।

भूमि तथा जलवायु

सर्पगन्धा विभिन्न तरह की मृदा अथवा दोमट मिट्टी, जलोढ़ दोमट मिट्टी में उपयुक्त होती है। कृषि वानिकी पद्धति में सागौन आधारित सर्पगन्धा की खेती के लिए भी यह मृदा उपयुक्त होती है। जो कि उच्च ताप को बड़े आसानी से सहन कर सकता है। ताप व नम जलवायु सर्पगन्धा की जैविक खेती के उपयुक्त है। सर्पगन्धा के लिए 10-38 अंश सेंटीग्रेड तापमान उपयुक्त होता है। साथ ही वार्षिक वर्षा 300-500 मि. मी. एवं वर्षा आधारित क्षेत्रों में इसकी बेहतर खेती की जा सकती है। सागौन के लिए यह उचित जलवायु एवं नमी तथा उष्णकटिबंधीय क्षेत्र उत्तम होता है। मृदा पी.एच. 8.5 से ज्यादा होने पर इसकी खेती करना उपयुक्त नहीं रहता है।

पौधे तैयार करना

इसके पौधे बीज, तने तथा जड़ की कटिंग द्वारा तैयार किये जाते हैं। बीज द्वारा तैयार करने पर जमाव बहुत कम होता है। ज्यादातर पौधों को जड़ों द्वारा तैयार किया जाता हैं। बरसात के शुरूआत में खेतों में पौधों की रोपाई कर दी जाती है।

लागत

सागौन के पौधों को खेतों की मेड़ों पर 5 x 5 मी. की दूरी पर लगाने पर लगभग 400 पौधे की प्रति हेक्टेयर आवश्यकता होती है।

पौधे के नाम	बुवाई का समय	दूरी	जैविक खाद	परिपक्वता का समय	उपज प्रति हेक्टेयर	आय प्रति हेक्टेयर (रू.)
Teak (सागौन)	अप्रैल-जून	5x5 मी.	22-45 टन/हे. गोबर की खाद	20-25 वर्ष	1200 कुन्तल	8,00,000
Sarpgandha (सर्पगन्धा)	अप्रैल-जून	30x15 मी.		20-25 टन/हे.	17-22 कुन्तल	2,55,000-3,30,000

सागौनवृक्ष के बीच अंतर, तने की काट-छांट समय-समय पर करते रहना चाहिए। काट-छांट में यदि देरी की गई या फिर पहले या ज्यादा कटाई-छंटाई की जाती है तो इससे इसकी खेती पर विपरीत प्रभाव पड़ता है। मेड़ों पर पौधरोपण करने से अतिरिक्त खाद सिंचाई आदि की आवश्यकता नहीं पड़ती है। खेतों में सिंचाई आदि करने से ही काम चल जाता है।

सर्पगन्धा के जड़ों की कटाई-छंटाई मुख्य रूप से 2-3 वर्षों में की जाती है। फूलों की तोड़ाई करने से जड़ों की पैदावार ज्यादा प्राप्त होती है। जड़े प्राप्त करने हेतु खेत में सिंचाई कर दी जाती है। प्रसंस्करण के लिए सूखी जड़ों का प्रयोग किया जाता है। सूखी जड़ों का आजकल बाजार में 300-400 प्रति किलोग्राम है। लगभग 7-9 कुन्तल प्रति एकड़ सूखी जड़ें प्राप्त होती है।

कृषिवानिकी में विभिन्न किस्म के औषधीय एवं सगंध पौधों की खेती की जा सकती है जिसका विवरण निम्नवत है।

वृक्ष के नाम	उत्पाद	उपयोग	औषधीय एवं सगंध पौधे के नाम	उत्पाद		उपयोग
				औषधीय	सगंध	
सागौन	बहुमूल्य इमारती लकड़ी, चारा, ईंधन	बहुमूल्य फर्नीचर व इमारतों में	सर्पगन्धा, पुदीना	जड़	पत्ती	विभिन्न प्रकार की बीमारियों, स्वास्थ्यवर्धक औषधीय एवं सौन्दर्य प्रसाधन, कास्मेटिक, इत्र उद्योग
पापलर	इमारती लकड़ी, चारा, ईंधन	पेपर, पल्प, लुग्दी बनाने में	अश्वगंधा, लेमनग्रास	जड़	पत्ती	
यूकेलिप्टस	इमारती लकड़ी,	पेपर, पल्प, लुग्दी बनाने में	कालमेघ, पामारोजा	बीज	पत्ती	
शीशम	सगंध पत्ती इमारती लकड़ी, चारा, ईंधन	बहुमूल्य फर्नीचर बनाने में	सतावर, खस	बेल तना पत्ती	पत्ती	
बांस	लकड़ी, पत्ती, चारा	हैंडीक्राप्ट एवं मैट, सजावटी वस्तु	घृतकुमारी, रोजमेरी, तुलसी	पत्ती	पत्ती	
कपोक	लकड़ी, फूल, रूई	ईंधन लकड़ी, काटन उद्योग	इसफगोल, पचोली	फल	पत्ती	
सहजन	फली, पशु चारा, छाल	गोंद एवं रेसिन, सब्जी एवं ईंधन	अश्वगन्धा, मेन्था	पत्ती	जड़	
सिरिस	लकड़ी, पशु चारा	इमारती एवं ईंधन लकड़ी	सतावर, खस	जड़	**जड़**	
आंवला	लकड़ी, फल	ईंधन लकड़ी, मुरब्बा, अचार, कैण्डी	सर्पगन्धा, सिट्रोनेला	जड़	पत्ती एवं तना	
बेल	लकड़ी, फल	ईंधन लकड़ी,आध्यात्मिक	सफेद मूसली,	जड़	तना, फूल एवं	

		(पूजा-पाठ) मुरब्बा, अचार, कैण्डी	जिरेनियम		पत्ती	
नींबू	लकड़ी, फल	ईंधन लकड़ी,तेल, अचार, मुरब्बा	कालमेघ, नींबू घास	पत्ती	पत्ती	
केला	फल, पत्ती	सब्जी, फल, आध्यात्मिक (पूजा-पाठ)	घृतकुमारी, पामारोजा	पत्ती	पत्ती, तना, फूल	

उपर्युक्त दिये गये कृषिवानिकी पद्धतियों के अन्तर्गत विभिन्न प्रकार के औषधीय एवं सगंध पौधे की व्यवसायिक खेती करके किसान अधिकाधिक रूप से लाभ एवं जैविक खेती के माध्यम से उच्च गुणवत्तायुक्त उत्पाद प्राप्त करके समृद्ध हो सकते हैं।

Tree and plants species for pollution management: A comprehensive review

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Abstract

Pollution management is a pressing global concern with significant environmental and human health implications. Due to anthropogenic activity on a worldwide scale, large quantities of particulate matter (PM) and heavy metals are collected in the air, water, and soil. Heavy metals (including cadmium, copper, lead, chromium, zinc, and nickel) accumulate up as a result of industrial processes such mining, smelting, refining, manufacturing, and excessive fertiliser uses in farmers' field. Among the various strategies employed to mitigate pollution, the use of tree species has gained attention due to their potential to absorb and remove pollutants from the air, soil, and water. By accumulating hazardous compounds, plants are a vital part of the environment's cleaning process.An efficient and widely accepted method for reducing pollutants and improving the environment is to plant trees and plants. For bioremediation of urban environmental pollution, careful planning and planting should be done. Depending on the amount and kind of pollution, it is important to choose pollution-tolerant and dust-scavenging trees and bushes.One such mitigation strategy is agroforestry (the common production of both plants and trees), avenue planting, vertical garden, and urban greening etc.The paper highlights the importance of selecting suitable tree species based on specific pollutant types and environmental conditions. Overall, this review contributes to the understanding of the role of tree species in pollution management and provides valuable insights for policymakers, researchers, and practitioners.

Keyword: APTI, Climate change, Mitigation, Pollution, Urban greening.

Introduction

Pollution is the most serious worldwide issue.With the rapid expansion in urbanisation, industrialization, and population growth over the past few decades, there has been a sharp increase in the pollutants of the air, water and soil pollution (Kirthika and Vishnuprasad, 2021).Urban landscapes that are sustainable and healthful are becoming more crucial for human well-being, including human health, ecosystems, climate, and visibility (Chen et al. 2019),is now a days one of the main atmospheric pollution problems, and it is getting worse due to urban population growth, rising traffic density, and industry (Gulia et al. 2015). Pollution management is a critical global challenge that demands effective and sustainable solutions. Among the various strategies employed to combat pollution, the utilization of tree species has emerged as a promising approach due to their inherent ability to absorb and remove pollutants from the environment. Trees play a crucial role in mitigating different types of pollution, including air pollution, soil contamination, and water pollution.Using some of the green plants to eliminate environmentally hazardous elements is known as phytoremediation, which is an ecologically beneficial and environment cleanup approach. In order to transfer and stabilise contaminants like pesticides, metals, and chlorinated hydrocarbons, it is one of the most affordable, simple, and environmentally friendly methods available (Randive and Jagtap, 2019).

Air pollution and its mitigation

The health of the environment can be measured by plants as bioindicators (Salih et al. 2017).Gaseous pollutants such as sulphur dioxide (SO2), carbon monoxide (CO), nitrogen oxides (NOX), ozone (O_3), lead (Pb), and particulate matter ($PM_{2.5}$ and PM_{10}) are examples of anthropogenic or natural pollutants found in the atmosphere. These pollutants are referred to as the criterion pollutant (Enitin at al. 2022). Precipitation, wind, particulate matter concentration and size of PM have an impact on how much particulate matter (PM) is deposited in the air (Pepek et al. 2019). In Delhi, Mumbai, and Kolkata, respectively, vehicular pollution makes up up to 70%, 52%, and 30% of all air pollution (Karthika and Vishnuprads, 2021). The term "green belt" refers to the widespread planting of pollutant-tolerant trees for the purpose of reducing air pollution by filtering, intercepting, and absorbing pollutants in a sustainable manner (Prajapati and Tripathi, 2008; Isaifan and Baldauf, 2021).The biochemical, physiological, and morphological characteristics of a plant determine its tolerance to air pollution (Singh and Verma, 2007).The ability of leaves to act as dust detectors is influenced by their surface geometry, phyllotaxy, epidermal and cuticular characteristics, leaf pubescence, and tree height and canopy (Nithya et al. 2017).Chen et al (2017) reported that the ability to trap $PM_{2.5}$ was highest in acicular (needle-shaped) leaves, followed by lanceolate leaves.The ability of plants to withstand air pollution is described by the air pollution tolerance index (APTI).It is one of the crucial factors that might be considered while choosing the species of plants for traffic barriers (Shrestha et al. 2021). Four biochemical factors have been used to describe plant APTI: total chlorophyll, relative water content (RWC), ascorbic acid, and pH of leaf extract (Nadgórska et al. 2017). The table 1 shows the APTI value of different tree species.

Formula for APTI estimation:

$$\text{APTI} = \frac{[A+(T+P)+(R)}{10}$$

Where, A= Ascorbic acid (mg g^{-1}), T= Total chlorophyll content (mg g^{-1}), P = pH of leaf extract, R= Relative water content (%)

Yang et al. (2015) found that the use of species with high $PM_{2.5}$ removal efficiency, particularly conifer species, has a significant deal of potential to improve the removal of $PM_{2.5}$from urbanair. Similarly, Kirthika and vishnupradas, (2021) reported that the Air Pollution Tolerance Index (APTI) values of plants are in decreasing order as follows: *P. roxburghii, P. pterocarpum, D. regia, P. longifolia, and A. scholaris* can be employed as bio-indicators of air pollution and in its mitigation for the creation of green belts in urban areas.

Table 1. List of trees with APTI value

S. No	Botanical name of tree species	APTI value	References
1.	*Peltophorum Pterocarpum, Albezia Lebbeck, Saraca asoca, Spathodia, Campunalata, Michelia champaka, Muntingia calabura, Cassia siamea, Pongamia pinnata, Delonix regia, Anacardium occidentale.*	12.85, 7.83, 16.56, 12.91, 10.76, 6.0, 11.65, 9.39, 7.39, 17.56	Kumar et al. 2018
2.	*Albizzia lebbeck, Cassia fistula, Zizyphus jujuuba, Azadirachta indica, Ficus religiosa, Psidium guajava, Phyllanthus emblica, Tamaridus indica, Moringa olifera, Delaonix regia, Tectona grandis, Morus alba*	32, 28, 25, 22, 20, 18, 14, 14, 12, 7, 6, 5	Kumar et al. 2013
3.	*Syzygium cumini, Michelia champaca, Acacia melanoxylon, Euculeptus sp., Ficus benghalensis, Delonix regia Raf., Morinda pubescens, Millingtonia hortensis, Leucaena leucocephala, Saraca indica, Caesalpinia pulcherrima, Dalbergia lanceolaria L.f., Ficus religiosa, Azadirachta indica, Pongamia pinnata (L.), Madhuca latifolia Roxb, Diploknema butyrace*	38, 32.6, 28.5, 24.2, 16.8, 14.5, 29.5, 15.6, 18.9, 14.7, 16.4, 32.5, 18.5, 35.6, 32.4, 34.6, 32.4	Begum et al. 2010
4.	*Acacia auriculiformis, Chrysophyllum albidum, Araucaria heterophylla, Mangifera indica L., Elaeis guineensis Jacq. Syzygium malaccense*	10.7, 10.4, 10.2, 8.03, 7.90, 4.79	Anake et al. 2019

Soil pollution and its mitigation

The functioning of ecosystems is adversely affected by soil contamination, which also poses threats to the environment and human health (Delerue et al. 2022). Soil pollution occurs due to various industrial and anthropogenic activity by which heavy metals/metalloids come from both natural and man-made sources, including the use of phosphate fertilisers in agriculture, sewage sludge, metal mining and smelting, the use of pesticides, electroplating, and the combustion of fossil fuels (Yan et al. 2020). Trees play a significant role in mitigating soil pollution through various mechanisms. They can absorb and accumulate pollutants, enhance soil microbial activity, and promote the breakdown and degradation of contaminants. In order to reduce soil erosion and stop the spread of pollutants to surrounding areas, tree roots help to bind soil particles together.Trees enhance the organic matter content, nutrient cycling, and water-holding capacity of the soil, which helps with soil restoration. Planting trees to restore contaminated soils can encourage the restoration of ecosystem services and functions. The avoidance and tolerance are two defence mechanisms used by plants to combat the toxicity of heavy metals (Yan et al. 2020).Plants initially attempt to immobilise heavy metals through root sorption or by altering metal ions when they are exposed to them. In the rhizosphere, a range of root exudates, including organic acids and amino acids, serve as a heavy metal ligand to create stable heavy metal complexes (Dalvi and Bhalerao, 2013). Trees can reduce soil pollution through a variety of methods, including phytoremediation (degradation of pollutants by metabolic mechanisms) Labe and Agera, 2017, phytostabilization (use of plant root to limit contaminant mobility and bioavailability in the soil) Jadia and Fulekar, 2009, photovolatilization (Plants change pollutants into less digestible forms), rhizodegradatio (degradation via microbialaction in the rhizosphere) (Labe and Agera, 2017; Yan et al. 2020). The example of some tree which is play significant role to mitigate the soil pollution is shown in table 2.

S. No.	Name of species	Heavy metals	References
1.	*Salix viminalis*, *Poplar* spp.,	Cd, Zn, Pb, and As	Hammer et al. 2003
2.	(*Populus deltoides x maximowiczii*-clone *Eridano and P. x euramericana*-clone	Zn, Cu, Cr and Cd	Sebastiani et al. 2004
3.	*Sasaella glabra, Sasa fortunei Sasa auricoma, Shibataea lanceifolia*	pb	Cai et al. 2021

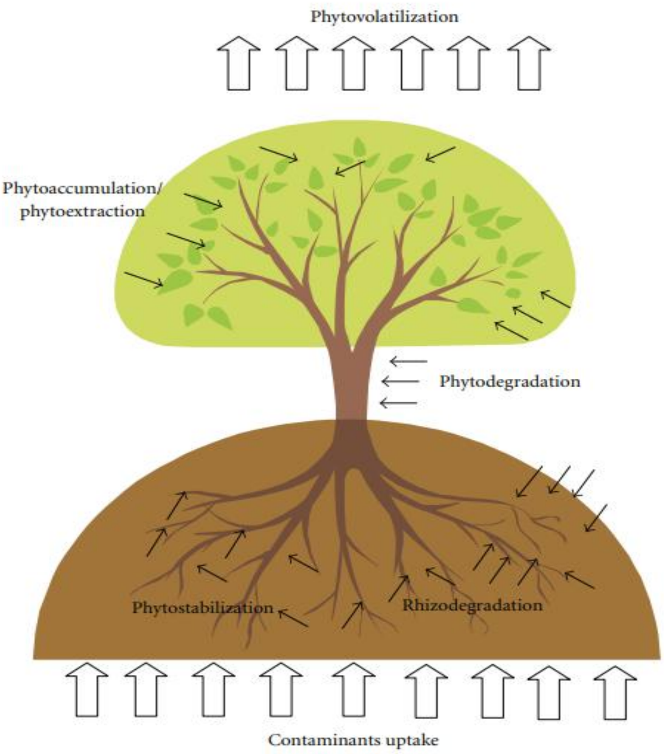

Fig: 1. The mechanisms of phytoremediation technique for heavy metal uptake by plants (Tangahu et al. 2011).

Water pollution and mitigation

Water shortage is an issue for about 40% of the world's population because of climate change, rising urbanisation, food demand, and unrestrained use of natural resources (Calzadilla et al. 2011).Rapid urbanisation, industrialisation, agricultural development, and the release of geothermal fluids and olive wastewater, particularly in places where olives are grown, increased the amount of toxic wastewater (Aguilar, 2009) such as heavy metals (HMs), oils, colours, phenol, cyanides, hazardous organic compounds, phosphorus, and suspended particles are all present in untreated industrial and domestic wastewater released into the environment (Rahman, and Hasegawa, 2011; Pakdel et al. 2018).Trees play a crucial role in mitigating water pollution through various mechanisms such as filtration, absorption, and biological processes. They can intercept and filter pollutants, stabilize riverbanks, and enhance water quality. In phytoremediation, plants collect pollutants through their roots and then move them to their aboveground parts of the body (Sharma et al. 2015). Aquatic plants serve as a natural absorber for pollutants and heavy metals (Pratas et al. 2014).The movement of water and pollutants via a vegetative filter strip can be a challenging procedure since it functionally consists of three distinct layers: the surface vegetation, the root zone, and the subsoil horizon. The efficiency of vegetative filter strips is influenced by field factors like soil type, rainfall frequency, slope, microtopography (surface soil roughness), infiltration capacity of the vegetated region, width of the strip, and height of the plants (Kumar et al. 2013). Pedescoll et al. (2015) found that the two rooted macrophytes *Typha angustifolia* and *Phragmites australis* removed 14–85% of heavy metals from municipal wastewater, including zinc, lead, arsenic, nickel, iron, copper, aluminium, and magnesium. Manjunath and Kousar (2016) studied that *pistia stratiotes*, *azolla pinnata*, and *salvinia molesta* are aquatic plants that have been proven to be particularly effective at removing Fe, Cu, and Mn from textile effluents at a concentration of 25%.

Table 3. List of plant and trees for water treatment

S. No.	Name of plant	Heavy metals	References
1.	*Calendula officinalis L.*	Cd and Pb	Tabrizi et al. 2015
2.	*Calendula alata Rech. fil.*	Cs and Pb	Borghei et al. 2011
3.	*Acacia nilotica, Acacia moniliformis Andrographis paniculate, Ageratum conyzoides, Barleria terminalis, Celosia argentea, Calotropis gigantean*	Cd Cr Ni Zn Pb and Cu	Randive and Jagtap, 2019
4.	*Hydrilla verticillate, Spirodela polyrrhiza, Bacopa monnierii, Phragmites karka, Scirpus lacustris, Azolla pinnata*	Pb, Cu, Cd, Fe, hg and chromium	Kumar et al. 2013
5.	Duckweed (Spirodela polyrhiza L	Arsenate and Dimethyl arsinic acid	Rahman et al. 2008

Conclusion

Large amounts of gaseous and particulate matter are removed from the atmosphere by the many tree species, acting as biological filters.Many of the suggested plants are keystone species that are essential to the growth and upkeep of the ecosystem.Urban trees have a big impact on environmental issues including air quality.The development of a green belt is aided by the planting of trees, which is seen as an effective approach for climate change adaptation and mitigation. Native tree species with specific ecosystem functions are chosen, and locations are deliberately chosen based on the advantages to human health and the environment.For the restoration of soil contaminated by toxic heavy metals, the use of trees as a plant cover appears to be significantly more successful.For the restoration of soil contaminated by toxic heavy metals, the use of trees as a plant cover appears to have significantly greater impact.

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An ideotype-a concept of model organism in forestry

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Introduction

C.M. Donald coined the phrase "ideotype" in 1968, and its literal meaning is "a form designating an idea." A biological model that is anticipated to function or react predictably in a certain setting is what he described it as. He defined a crop ideotype as a plant model that is anticipated to produce more grain, oil, or other valuable product when produced as a cultivar. Crop ideotypes are also known as "model plants," "ideal plants," and "model plants".In general, ideotype is described as "a model plant equipped with all such characters to give maximum yield under given environment" (Singh, 2016).

In 1976, Donald and Hamblin put forth the ideas of seclusion, rivalry, and societal or agrarian ideotypes. The model plant type that works best when plants are arranged spatially is the isolation ideotype. At crop densities, it is unlikely to function effectively. The competition ideotype is the one that thrives in a population with a diverse genetic make-up. Because it is a weak competitor, crop ideotype thrives best at commercial crop densities. It functions best when only plants of the same shape are in its immediate vicinity (Singh, 2016).

In 1968 Donald proposed several other ideotype conceptswhich includes traits of specific features i.e., market ideotype has the qualities that determine the market acceptability of produce; climatic ideotype includes the traits important in climatic adaptation, edaphic ideotype, stress ideotype and disease or pest ideotype etc (Singh2016).

Development of tree ideotypes

C.M. Donald 1968 suggested that the basic ideotype should be first developed for optimum, non limiting environment. Based on Donald's formulation first ideotype was developed in wheat, then many other crop ideotypes have been derived e.g.barley (Rasmusson, 1987), Chickpea (Siddique and Sedgley, 1990) including forest trees such as spruce and pine (Karki and Tigerstedt 1985) etc.,

The development of ideotype in forest trees was formulated by Dickman in 1985 and he described it as ""the first step towards bioengineering an improved plant," in which a combination of characteristics serves as a guide for selecting prospective breeding material from natural populations.He also emphasised that ideotype is not a wishful creation based on unverified ideas or beliefs;rather, it is a deductive result based on a thorough grasp of plant biology, physiology and morphology (Leaky and Page, 2006).

Based on Dickman's concept many ideotypes have been developed as far. Domestication of timber trees has often relied on a mix of provenance and progeny selection, which may be a time-consuming procedure, especially for improving component traits under quantitative genetic control. Dickman *et al.*, (1994) stated that an ideotype may be regarded a single quantitative attribute in which individuals are picked for their degree of fit to the ideotype and captured by clonal propagation to overcome this challenge. Both cultivated and wild populations are included, although fast genetic gains are feasible. Cloning has historically been used to cultivate a few species (such as Populus, Salix spp., and *Cryptomeria japonica*), and it has recently been expanded to a number of additional species. This clonal strategy to tree development is especially crucial for traits that, due to their non-additive inheritance, are difficult to preserve through sexual reproduction. The application of the ideotype idea to conceptualise combinations of frequently unrelated qualities aids this clonal approach to tree development (Dickman 1985). The development of an ideotype is therefore not static, as it requires an iterative cycle of formulation, application, evaluation and reformulation (Leakey & Page, 2014).

Dickmann (1985) and Dickmann & Keathley (1996) published the Populus ideotype, which incorporates a lot of nonmorphological information. The Populus ideotype's ideal silvicultural context is a high-density, non-irrigated plantation developed for energy or wood fibre. This ideotype, one of just a handful for forest trees, has a broad list of desired attributes in a variety of areas, including growth and physiology, ecological characteristics, morphology, stem and wood properties, and root characteristics. Kärki and Tigerstadt's (1985) generalised that Scandinavian conifer ideotype has many traits with the Populus ideotype, but with less focus on physiological actors(Timothy*etal*.,2001).In *Piceaabies* and *P. sylvestris* (Karki ,1985) found that extremely narrow crowned trees produce both high quality timber and a high yield per hectare. In west and central Africa, 'fruit' and 'kernel' ideotypes have been identified in *Irvingiagabonensis* (Bush Mango), based on quantitative characterisation of a number of fruit, nut and kernel traits.In Australia, a very broad-based ideotype has been developed for the indigenous shrub *Kunzeapomifera* (Muntries) established on both morphological and physiological traits. Similar approaches are identified for timber trees (e.g.*Triplochiton scleroxylon*) and those like *Santalum austrocaledonicum* producing essential oils. There is still a huge scope in wild trees to tap their variation and develop ideotypes that are well suited for the environment and yield commercial profits based on the usage (Leaky and Page2006)

Advantages of ideotype

Aside from offering a clear, well-defined purpose for a breeder, there are other reasons to invest time and money in the development of ideotypes. Donald (1968) proposed that ideotypes allow breeders to create and test combinations of traits that would otherwise not occur in their plots for decades. A consequence, more important to tree breeders, is that an ideotype may be used to guide the selection of potential breeding material from natural populations.Furthermore forest tree ideotype for wood yield is a polygenic character; only by breaking yield down into its componentsand systematically dealing with them one by one canbecome a major break-throughs in tree improvement (Ford *et al.*, 1976).

Ideotypes specify explicitly the morphological or other traits that tree breeders should be seeking in their selections. If the ideotype is based on good biological information, these traits could potentially be better linked to rotation-age yield than traditionally measured parameters such as growth in genetic tests that are typically measured at one-fourth to one-half rotation age (Dickmann and Keathley, 1996).

In particular, most genetic tests are designed such that each family or clone occupies a very small plot with only one to a few trees (e.g., Loo-Dinkins and Tauer 1987, White and Hodge 1992), and selections are often based on juvenile growth (Lambeth *et al*.,1983, McKeand 1988, Burdon 1989).This means that nearly all selections currently practiced in tree improvement programs are a form of indirect selection (Falconer and Mckay1996), because the selection criterion (juvenile growth in small plots) is distinct from the target trait. Genetic gain from indirect selection depends in part on the heritability of the traits in the selection criteria and their genetic correlation with the target trait (Falconer and McKay1996). By giving breeders an explicit description of the traits of a southern pine crop ideotype based on harvest-aged yield, an ideotype-based approach could help overcome selection biases and better direct breeders to selection of promising phenotypes, which may not always be the largest or best performing trees in wild populations or in progeny test environments.

The following benefits might arise specifically from the definition of a thorough southern pine crop ideotype based on underlying biochemical, physiological, or morphological traits;

1. If underlying traits are more closely related to the genome and less affected by environmental noise, they may have higher heritabilities than growth traits currently in use;
2. If they are less affected by selection age they may have higher genetic correlations with the target trait (the rotation-age crop ideotype);
3. Basing selection on underlying traits composing the crop ideotype may allow for greater predictability and efficiency.
4. Breeders might improve mating designs beyond the blind breeding currently used, by allowing them to create complementary crosses (such as a cross between a selection that tends to maximise leaf-level photosynthetic rates and another that tends to maximise leaf area development).
5. Moreover, by explicitly combining our knowledge of the structural and functional factors influencing development, ideotypes may be used as a foundation for understanding the physiology of tree production.

The conceptual model of the ideotype functions as a framework for synthesis, much like process models. The interaction between geneticists, tree breeders, and physiologists is also facilitated by ideotypes, which should result in a more effective application of the findings from fundamental physiological and genetic research.

Constraints in development of tree ideotype

While production of trees and forests is exhibited at the level of the individual tree and the stand, respectively, physiological research predominantly focuses spatially at the organ level and below. While forest growth occurs over periods of years and decades, physiological study frequently concentrates on time ranges of seconds to hours. The formation of tree ideotypes is also hampered by the lifetime of trees. Physical barriers that prevent their research include the size, depth, and distance from the ground of tree canopies. Additionally, tree canopies are typically more complicated than other crop canopies due to their horizontal and vertical heterogeneity (Parker *et al.*, 1995), which makes measurement of them more challenging than with agronomic crops.

Conclusion

Forest management will be seen as another instance of intense cropping, with agriculture differentiating only in terms of the duration of the rotation and the type of economic output. To effectively utilise the capabilities oftrees must be genetically altered to work in intensive cropping systems. Implementing the ideotype notion can offer accurate descriptive models towards which tree breeders should strive, improving the effectiveness of tree development initiatives. Using ideotypes has a lot of potential benefits, despite issues with its design and implementation.

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Enhancing plant resilience in the face of drought stress: Strategies and approaches for mitigation

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Abstract

Drought stress is a significant environmental challenge that negatively affects plant growth, development, and productivity. As global climate patterns continue to shift, the frequency and severity of drought events are expected to increase, posing a threat to agriculture and natural ecosystems. This article explores the adverse effects of drought stress on plants and discusses various strategies and approaches that can help alleviate its impact. From physiological adaptations to agronomic practices and molecular interventions, ranges of techniques are available to enhance plant resilience and productivity in drought-prone conditions.

Keywords: adaptation, drought, resilience, stress

Introduction

Drought stress poses a significant challenge to plant growth, development, and agricultural productivity, particularly in regions prone to aridity or experiencing changes in climate patterns. Drought stress occurs when plants experience inadequate water availability to meet their physiological needs, leading to reduced photosynthesis, impaired nutrient uptake, cellular damage, and compromised growth and yield. As climate change continues to unfold, the frequency, duration, and severity of drought events are expected to increase, exacerbating the vulnerability of plants and agricultural systems.

Understanding the adverse effects of drought stress on plants is crucial for developing effective strategies to mitigate its impact. Drought stress can have far-reaching consequences, affecting not only crop yield and food security but also ecosystems, water resources, and rural livelihoods. Addressing this challenge requires a multi-faceted approach that combines scientific knowledge, technological innovations, and sustainable agricultural practices.

In recent years, research efforts have focused on identifying strategies and approaches to enhance plant resilience and mitigate the adverse effects of drought stress. These strategies encompass a wide range of interventions, including physiological adaptations, agronomic practices, and molecular interventions. By understanding the underlying mechanisms of plant response to drought stress, researchers and farmers can implement targeted measures to enhance plant tolerance and minimize yield losses.

Furthermore, the development and adoption of drought-tolerant crop varieties through traditional breeding techniques and genetic engineering offer promising avenues for improving crop performance under limited water availability. Additionally, sustainable agricultural practices such as improved irrigation management, soil moisture conservation, and integrated water resource management can help optimize water use efficiency, reduce losses, and ensure the sustainable use of water resources.

As we navigate the complexities of drought stress, it is essential to explore innovative approaches and advance our understanding of plant responses to water scarcity. This article aims to delve into the adverse effects of drought stress on plants and examine various strategies and approaches for mitigating its impact. By embracing these strategies, we can enhance plant resilience, ensure agricultural sustainability, and contribute to food security in the face of increasingly challenging environmental conditions.

Effects of drought stress on plants

Drought stress affects plants at various levels, including cellular, physiological, and biochemical processes. Some common effects of drought stress on plants include:

- Reduced photosynthesis and carbon assimilation: Drought stress often leads to stomatal closure, reducing the entry of CO_2 into leaves and limiting the energy available for plant growth.
- Stomatal closure and reduced transpiration: As a survival mechanism, plants close their stomata to reduce water loss, resulting in decreased transpiration rates and limited nutrient uptake.
- Accumulation of reactive oxygen species (ROS) and oxidative stress: Drought stress disrupts the balance between ROS production and scavenging, leading to oxidative damage and cellular dysfunction.
- Impaired nutrient uptake and assimilation: Drought stress restricts nutrient availability by reducing water movement in the soil, impairing nutrient uptake and limiting their transport within the plant.
- Altered hormonal balance and growth regulation: Drought stress affects hormonal signaling pathways, leading to changes in plant growth, development, and reproductive processes.
- Decreased crop yield and quality: Drought stress significantly reduces crop yield, affecting both quantity and quality of harvested produce.

Strategies and Approaches for alleviating drought stress

Physiological Adaptations

- Root system modifications to enhance water uptake efficiency: Promoting deeper and more extensive root systems can improve water acquisition from deeper soil layers.
- Stomatal regulation through improved stomatal control and water-use efficiency: Breeding or genetic engineering approaches can enhance stomatal sensitivity to environmental cues, allowing for better control of water loss.
- Osmotic adjustments and accumulation of compatible solutes for osmoprotection: Some plants can synthesize compatible solutes, such as proline or sugars, which help maintain cellular hydration and protect proteins and membranes.

- Activation of antioxidant systems to mitigate oxidative damage: Enhancing the activity of antioxidant enzymes or increasing the production of antioxidants can counteract the detrimental effects of ROS.

Agronomic practices

- Irrigation management techniques such as deficit irrigation and precision irrigation: Optimizing water application based on crop water requirements can improve water-use efficiency and minimize water stress.
- Mulching to conserve soil moisture and reduce evaporation: Applying mulch on the soil surface helps to retain moisture, suppress weed growth, and regulate soil temperature.
- Crop rotation and diversification for improved water use and resilience: Rotating crops with varying water requirements can balance water use and minimize the risk of drought stress.
- Conservation tillage to enhance soil water-holding capacity: Reducing soil disturbance through conservation tillage practices helps preserve soil structure, enhance water infiltration, and reduce evaporation.

Molecular interventions

- Breeding and selection for drought-tolerant varieties through marker-assisted selection: Identifying and selecting plants with genetic traits associated with drought tolerance can expedite breeding efforts.
- Genetic engineering for the introduction of drought-responsive genes: Transferring genes involved in stress tolerance, such as those responsible for osmotic adjustment or stomatal regulation can enhance plant drought tolerance.
- Application of plant growth-promoting substances and biofertilizers: The use of beneficial microorganisms or biostimulants can enhance plant growth, nutrient uptake, and stress tolerance under drought conditions.
- Use of exogenous compounds like osmoprotectants and plant growth regulators: Applying osmoprotectants, such as glycine betaine or polyamines, or plant growth regulators like abscisic acid (ABA), can enhance plant drought tolerance.

Challenges and future directions

Implementing strategies to mitigate drought stress in plants faces several challenges, including:

- Complex genetic basis of drought tolerance and limited understanding of underlying mechanisms: Unraveling the genetic basis of drought tolerance and identifying key genes and regulatory pathways involved remain complex tasks.
- Translating research findings into practical applications for different crops and environments: Strategies developed in research laboratories must be tailored to specific crops, cultivation practices, and environmental conditions for effective implementation.

- Balancing drought tolerance with other desirable agronomic traits: Breeding for drought tolerance should consider trade-offs with other important traits, such as yield potential, disease resistance, or nutritional quality.
- Ensuring the affordability and accessibility of drought mitigation techniques for farmers, especially in developing regions: Practical solutions must be cost-effective and easily adoptable by resource-limited farmers to ensure equitable access to drought mitigation strategies.

Conclusion

Drought stress poses a significant threat to plant productivity and ecosystem stability. However, by employing a combination of physiological adaptations, agronomic practices, and molecular interventions, the adverse effects of drought stress can be mitigated. Continued research, innovation, and collaboration among scientists, breeders, policymakers, and farmers are vital to developing and implementing effective strategies to enhance plant resilience and ensure sustainable food production in drought-prone regions.

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Insects associated with sal seeds

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Abstract
Shorea robusta Gaertn. f. (family Dipterocarpaceae), commonly known as sal in India, is a large deciduous, resiniferous tree having majestic shining foliage. Of about 346 insects recorded on sal, about 155 species are associated with living sal tree. There are 19 insect species which feed on the flower and seed. Out of the total number of seed insect species, 2 species feed on flower, 12 feed on the seed while they are on the standing tree and 5 insect species attack the seed when fallen in the ground or during storage. The major seed insects are described in this article. Further, the role of seed feeding insects in sal regeneration is highlighted.

Key words: Sal, *Shorea robusta*, seed insects.

Introduction
Shorea robusta Gaertn. f. (family Dipterocarpaceae), commonly known as sal, is one of the most important timbers of India both ecologically and economically (Anon, 1972; Tewari, 1995). The tree yields timber which is largely used for construction work and mining operations. It is used as beams, columns, bridges, poles, roofing, doors and window frames, etc. Lops and tops of sal are very good fuel. Sal tree exudes an oleoresin, which is used in paints and varnishes. The seeds contain 12 to 19 % fat and oil extracted from seeds is used in soap making. Sal seed, a valuable minor forest produce in the state of Madhya Pradesh and Chhattisgarh, is collected to tune of approx. 50,000 tonnes annually which values about Rs. 20 crores (Anon, 1997).

Of about 346 insects recorded on sal, about 155 species are associated with living tree, encompassing mainly defoliators (114), seed-feeders (19) borers (18), and sap-suckers (4) (Stebbing, 1914; Beeson, 1941; Mathur and Singh, 1960; Browne, 1968; Anon, 1972; Srivastava et al., 1984; Sen-Sarma and Thakur, 1994; Thakur, 2000; Nair, 2007; Roychoudhury, 2015). The present article deals with insects feeding on seeds of sal, *S. robusta*.

Seed feeding insects of sal
Based on the nature of damage, insect species feeding flowers, inflorescence and those feeding seeds on the tree and during storage are included in this category. There are 19 insect species which feed on the flower and seed (Beeson, 1941; Mathur et al., 1958; Mathur and Singh, 1960; Browne, 1968; Thakur, 2000; Roychoudhury, 2015) (Table 1). Out of the total number of seed insect species, 2 species feed on flower, 12 feed on the seed while they are on the standing tree and 5 insect species attack the seed when fallen in the ground or during storage. Srivastava et al. (1984) have recorded two species of thrips, viz. *Thrips flavus* Schrank (Thysanoptera: Terebrantia) and

Haplothrips ganglbaueri Schmutz (Thysanoptera : Tubulifera) in the flowers of *S. robusta*. Most important among seed insects are 'seed and seedling borer' *Pammene theristis* Meyrick (Lepidoptera: Eucosmidae) (Beeson, 1941), *Dichorocis leptalis* Hampson (Lepidoptera: Pyralidae) and *Lamoria adaptella* Walker (Lepidoptera: Pyralidae) feeding on seed while they are on the tree. Caterpillars of *Blastobasis crassifica* Meyrick, *B. molinda* Meyrick, *B. ochromorpha* Meyrick and *B. spormologa* Meyrick (Lepidoptera: Blastobasidae) also take a significant toll of fruits and seeds, rendering them non-viable (Sen-Sarma and Thakur,1994). *Sitophilus rugicollis* Casey (syn. *Calandra rugicollis*) (Coleoptera: Curculionidae) (Browne, 1968), *Alphitobius laevigatus* Fabricius (Coleoptera: Tenebrionidae) *Gonocephalus planatum* Walker (Coleoptera: Tenebrionidae), *Mesomorphus striolatus* Fairmaire and *Cocotrypes integer* Eichhoff (Coleoptera: Scolytidae) damage seed either on the forest floor or during storage.

Table 1: Insects associated with sal seeds

Insects*	Order	Family	Insect species
Seed-feeders (19)	Coleoptera (6)	Cuculionidae (2)	*Apoderus tranquebaricus* Fabricius *Sitophilus rugicollis* Casey
		Scolytidae (1)	*Coccotrypes integer* Eichhoff
		Tenebrionidae (3)	*Alphitobius laevigatus* Fabricius *Gonocephalum planatum* Walker *Mesomorphus striolatus* Fairmaire
	Lepidoptera (11)	Blastobasidae (4)	*Blastobasis crassifica* Meyrick *Blastobasis molinda* Meyrick *Blastobasis ochromorpha* Meyrick *Blastobasis spermologa* Meyrick
		Eucosmidae (2)	*Enarmonia pulverula* Meyrick *Enarmonia theristis* Meyrick
		Gelechidae (2)	*Brachmia resoluta* Meyrick *Brachyachma palpigera* Walsingham
		Pyralidae (3)	*Dichocrosis leptalis* Hampson *Ephestia* sp. *Lamoria adaptella* Walker
	Thysanoptera (2)	Terebrantia (1)	*Thrips flavus* Schrank
		Tubulifera (1)	*Haplothrips ganglbaueri* Schmutz

*Based on the nature of damage. Figures inside parentheses indicate number of species.

Of these, the caterpillars of *Dichocrocis leptalis* and *Pammena theristis* bore the mature seeds and the weevils of *Sitophilus rugicollis* cause a severe damage to the stored and nursery sown seeds. A brief account of these major species of seed borer is mentioned as hereunder.

Dichocrocis leptalis

Hampson (Lepidoptera: Pyralidae)

The moths of this insect lay egg on the developing seeds of sal in July. The larva enters inside the seed and feeds on kernel. After consuming the entire kernel of a seed, the larva bores another seed. The infestation continues in stored or sown seeds till the month of September-October.

Pammene theristis

Meyrick (Lepidoptera: Tortricidae)

The medium sized moth has a wingspan of 15 mm. It is dark blue and grey colour moth which lays eggs on the seeds. According to Chatterjee and Thapa (1970), its moth oviposits on the seeds in April-May and develops to moths of 2nd generation in May-June. They again oviposit eggs of 3rd generation which develop moths of 3rd generation in June-July. They oviposit eggs on seeds which develop to moths of 4th generation in July–August. They again oviposit on seeds of sal which develop moths of 5th generation in August September. They again oviposit which hatch to larvae and ultimately to the moths of 6th generation in September-October. These moths oviposit and the larvae bore to tap roots. The development continues up to March and moths emerge in March-April. Its larva is whitish and feeds on the seeds up to the 6th generation. Its 7th generation, however, feeds on roots and shoots of seedlings and saplings from September - October to March-April (Thakur, 2000).

Sitophilus rugicollis

Casey (Coleoptera: Curculionidae)

The weevils come out from the soil during June-July, when they get young newly felled sal seeds, they oviposit the eggs. The freshly hatched grub penetrates inside the seed without leaving a sign of entrance hole. The larva feeds the kernel and ultimately develops to weevil, which comes out from the seed by making a circular exit hole (Fig. 1). The weevils continue to breed in stored seeds in September-October. Khatua and Chakarborti (1990) have observed that the weevils aestivate in soil from September to May.

Fig. 1. Sal seeds damaged by *Sitophilus rugicollis*

Sal regeneration and role of seed feeding insects

The regeneration of sal is a complex and baffling problem (Bisht, 1989). Despite having a wide niche, the species has a great regeneration problem due to various anthropogenic disturbances, limitations of soil moisture, over mature stands and both inter and intra-specific competitions (Chauhan et al., 2008). According to Sen-Sarma and Thakur (1994) that the problem of failure of regeneration in sal may be the cumulative effects of abiotic and biotic factors, *P. theristis* and *S. rugicollis* probably play a prominent role.

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