Draft Study Material

BAMBOO GROWER

(Qualification Pack: Ref. Id. AGR/Q6101)

Sector: Agriculture

(Grade IX)

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PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION
(a constituent unit of NCERT, under Ministry of Education, Government of India)
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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

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Table of Contents

PSCVE Draft Study Material © Not to be Published

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Module 1	Introduction to Bamboo

Module Overview

Module 1 on introduction to bamboo provides a comprehensive overview of the socio-economic and environmental benefits of bamboo and rattan, along with insights into their anatomy and physiology. In Session 1, you will learn about the various socio-economic advantages of bamboo, such as poverty alleviation, employment generation, and community development. In Session 2, the anatomical structures of bamboo, like stems, leaves, and roots, which contribute to its unique strength and growth adaptability have been dealt with.

Learning Outcomes

After completing this module, you will be able to:

- Describe the multifaceted uses of bamboo.
- Explain the socio-economic benefits of bamboo.
- State the environmental benefits of bamboo.
- Identify the commercially viable varieties of bamboo in India.

Module Structure

Session 1: Bamboo and Its Benefits

Session 2: Fundamental Parts of Bamboo

Session 1: Bamboo and Its Benefits

You might have seen tall, woody plants that resemble grasses but are not true grasses, as they grow densely and form thick clusters. These plants are called Bamboos in English, *Bans* in Hindi, *Bansa* in Bengali, *Mula* in Tamil *Moongil* in Nepal, and many other names in local vernacular languages.

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Bamboo **(Figure 1.1)** is a versatile plant that naturally thrives on every continent except Europe and Antarctica. India, home to the world's second-largest bamboo resource, boasts about 150 species dispersed across the country. The majority of these species flourish in Northeast India, with Assam leading in bamboo production. This region also has the largest bamboo-growing area in the country, where bamboo is deeply embedded in cultural practices and traditions. In states like those in the Northeast, bamboo is so integral to daily life that it is often regarded as a lifelong companion, supporting people from birth to death. Following the Northeast, the Western Ghats region has the second-highest diversity of bamboo species in India.

Figure 1.1: Bamboo plant

Bamboo is grown in private plantations and on community land. Indian bamboos grow in a wide range of habitats, and at altitudes ranging from sea level to over 3,000 meters. It is a resource that can generate income and employment, especially in backward areas and amongst disadvantaged communities.

Bamboo is also known as a "plant with a thousand faces" because of its multiple uses and has played a significant role in human society since ancient times.

Bamboo in Tradition and Culture

Bamboo is intricately associated with the culture and tradition of many Asian countries. In some parts of India, bamboo is also called *'Kalpavirksha'* or divine tree due to its numerous uses in daily life in physical as well as in spiritual form. The use of bamboo in rituals of birth and death persists in some parts of the world. In many states of India, especially North-East states, bamboo is intricately related to culture. So many social activities are connected to bamboos that people consider it as a friend that serves them from cradle to coffin.

In Indian culture, the bamboo flute called *Bansuri* (Bans- bamboo and Sur- music) was used to play music by Lord Krishna since the time of Mahabharata. Bamboo is also involved in the rituals of some Indian weddings. For people from southeast Asian countries, bamboos symbolize gentleness, modesty, serenity, and purity and bestow good luck upon the people. Apart from its traditional uses, bamboo has various new applications as an alternative to wood and other more expensive materials like steel, iron, etc. It is widely used in construction, either in its natural form or as a reconstituted material, laminated boards, and panels composite of bamboo and plastic.

Bamboo Handcraft and Other Items

The bamboo industry is an industry related to our Indian heritage culture. In ancient times, the business of handicrafts and handloom industry was spread all over the world. The various items that are prepared from bamboo include the following:

Furniture

Bamboo furniture such as chairs, sofa sets, and beds are relatively low priced compared to timber products. They are particularly suitable for tourism and household uses **(Figure 1.2).**

Figure 1.2: Bamboo furniture

Bamboo Art and Craft

Bamboo handcraft art is called bamboo handicrafts; this industry is called the Handicraft Industry.

Woven Bamboo Products

Woven bamboo products, which range from baskets and mats to furniture and decorative items, are crafted by weaving thin bamboo strips into intricate patterns. The weaving techniques vary by region, often reflecting local traditions and cultural aesthetics. Bamboo weaving supports eco-friendly craftsmanship, as bamboo is a renewable resource that grows quickly and requires minimal resources. The production of woven bamboo items offers significant socio-economic benefits, especially for rural communities, by providing sustainable livelihoods and preserving traditional skills. Additionally, these products are durable, biodegradable, and environmentally friendly, making them popular in both domestic and international markets. The artistry and functionality of woven bamboo items have also inspired modern designers, who incorporate bamboo into contemporary décor and lifestyle products.

Figure 1.3: Bamboo baskets

(a) Baskets: Bamboo baskets **(Figure 1.3)** are a versatile and traditional craft with a rich history, often made by hand using techniques passed down through generations. These baskets are woven from bamboo strips, which are flexible yet sturdy, making them ideal for various uses, from storage to decorative items.

(b) Bags: Bamboo bags are lightweight yet strong, commonly used as fashionable accessories or practical storage options.

(c) Mats: Woven bamboo mats are used as floor coverings or placemats, valued for their durability and natural beauty.

Musical instruments

Traditionally many musical instruments are made of bamboos. Bamboos are perfect for making woodwind instruments Most notably, traditional wooden flutes are made of bamboos **(Figure 1.4).**

Figure 1.4: Musical instruments made of bamboo

Bamboo Pens

Bamboo pens provide an environmentally friendly alternative to plastic pens. Often handmade, these pens feature smooth finishes and natural designs. They are functional while also helping to reduce plastic waste.

Bamboo Vases

Bamboo vases are elegant and eco-friendly, often used as decorative pieces in homes or offices. These handcrafted items showcase the natural grain of bamboo, offering a rustic yet sophisticated look.

Bamboo Ornaments

Bamboo is frequently used to craft decorative items like sculptures, wall art, and figurines. These intricately carved or shaped pieces enhance the aesthetic value of homes and other spaces.

Social and Economic Benefits of Bamboo and Rattan

Social and economic benefits of bamboo and rattan include the use of bamboos in building houses, schools and other construction purposes, such as bamboo fencing, scaffolding, boat making, flooring, etc. Their wide range of uses in construction and other industries can stimulate local economies, enhance living conditions, and provide environmentally friendly alternatives to traditional building materials.

(i) Social Benefits

a) **Job Creation**: The cultivation, processing, and construction of bamboo and rattan create numerous employment opportunities, especially in rural regions. This includes harvesting, processing, weaving, and turning bamboo and rattan into various products, providing livelihoods for many, particularly in parts of Asia and Africa.

b) **Preservation of Cultural Heritage**: Bamboo and rattan play a crucial role in the cultural heritage of regions such as Southeast Asia and Africa, where they are integral to traditional building methods. Using these materials helps safeguard indigenous skills and knowledge, promoting community cohesion.

(ii) Economic Benefits

a) **Sustainable Industry Growth**: Bamboo and rattan are renewable resources that grow significantly faster than hardwood trees (bamboo can grow up to 3 feet per day). Their rapid growth supports sustainable economic development, particularly in forestry and construction, while reducing the strain on slower-growing timber resources.

b) **Export Opportunities**: Bamboo and rattan products, such as furniture, flooring, and handicrafts, hold strong export potential, especially in eco-conscious markets. Countries like China, India, and the Philippines benefit from exporting these goods, boosting their economies.

c) **Cost Savings**: Bamboo's flexibility and strength make it an efficient building material, reducing both material and labour costs. Its lightweight nature lowers transportation expenses, and its ease of use accelerates the construction process.

(iii) Environmental Benefits

Planting bamboo to control soil erosion is recommended in areas susceptible to landslides or slopes in the process of slowly losing its soil. Bamboo plants with their interwoven system of roots and rhizomes contribute to the recovery and conservation of soils present on riverbanks. Beneath the ground lays an extensive network of rhizomes that ties together and prevents soil erosion on hillsides or river banks. Besides these benefits, there are many other ecological and environmental benefits, which include the following:

a) **Carbon Sequestration**: Bamboo and rattan absorb large amounts of carbon dioxide, contributing to efforts against climate change. This reduces the carbon footprint of construction projects that use these materials.
b) **Renewable and Fast-growing**: Bamboo matures quickly, within 3-5 years, compared to hardwood trees, which take decades. Its fast regrowth ensures a sustainable supply without depleting natural resources.

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c) **Promotes Biodiversity**: Bamboo forests provide habitats for wildlife and can help rehabilitate degraded lands. When managed sustainably, bamboo and rattan plantations enhance soil health and water retention, contributing to overall ecological sustainability.

Use of Bamboo in Construction and Infrastructure Development

a) **House Construction**: Bamboo is commonly used in house building, especially in areas prone to earthquakes due to its flexibility and strength. It is used for structural components like walls, floors, and roofs. Rattan is sometimes paired with bamboo to create lightweight yet durable building materials.
b) **Public Infrastructure (Schools, Community Centres)**: Bamboo's affordability and quick availability make it an excellent choice for constructing public infrastructure, such as schools, community centres, and healthcare facilities. It is durable and can be treated to resist pests, ensuring long-lasting structures.
c) **Bamboo Flooring**: Bamboo is gaining popularity as an eco-friendly alternative to hardwood flooring. It is durable, cost-effective, and has a lower environmental impact due to its fast regrowth.
d) **Bamboo Fencing**: Bamboo is a popular material for fencing because of its natural strength, durability, and aesthetic appeal. Bamboo fences are environmentally friendly, affordable, and easy to install, making them a preferred choice in both rural and urban settings.
e) **Scaffolding**: Because of the incredible tensile strength of bamboo to weigh ratio bamboo wood is being used for making scaffolds for construction and versatile equipment by the farmers. It is often used for scaffolding because it proves to be an eco-friendly and cost-effective resource. In Hong Kong, bamboo scaffolding is preferred over metal scaffolding because it's easily available and cheaper.
f) **Boat Making**: Bamboo's water-resistant qualities make it an ideal material for lightweight boats and rafts, particularly in areas reliant on water-based transport. Rattan is also used to reinforce these structures.
g) **Bridges and Walkways**: Bamboo is used to build pedestrian bridges, especially in rural areas where steel or concrete is scarce. Its strength and flexibility make it suitable for spanning small rivers and other bodies of water.

Others Uses of Bamboo

a) **Paper Making:** Ancient civilizations have used bamboo strips for writing. Due to its good fibre qualities, bamboo is used for making pulp and paper in China, Myanmar, Thailand, and India.

b) **Utensils:** Cups and saucers, spoons, forks, ladles, bottles, and tiffin can all be made from this incredibly versatile material. Chopsticks, tongs, chopping

boards, and many cutlery items are also made from bamboo. Bamboo is being looked upon as an alternative to replace plastics.

(c) Bamboo straws and tooth brushes

Bamboo straws and toothbrushes are excellent eco-friendly alternatives to plastic products, helping to reduce waste and promote sustainability. Bamboo straws are biodegradable, durable, and reusable, offering a stylish touch to beverages while being made from a fast-growing, renewable resource. Similarly, bamboo toothbrushes feature soft bristles that are gentle on teeth and gums, while their biodegradable handles break down naturally, unlike plastic **(Figure 1.5).**

Figure 1.5: Bamboo straws and tooth brushes

(d) Food

Bamboo is an important source of food, both for humans and animals. The young, immature emerging vegetative aerial culms are generally called shoots. Among the animals, giant pandas and golden lemur feed almost exclusively on bamboo. Seeds and young shoots are consumed as food by humans. Young bamboo shoots are crispy and delicious and are used in fresh, dried, or fermented forms. Moreover, they are rich in nutrients like proteins, carbohydrates, amino acids, minerals, vitamins, and health-promoting bioactive compounds due to which bamboo shoots are now known as a "superfood".

Fresh shoots are mostly used for making soups, curries, salads, pickles, and other stewed and fried dishes. In India, bamboo shoot consumption is very popular in North-Eastern regions of India and some parts of south and central India.

The young shoots of bamboo are also used to make value-added nutrient-rich food products like biscuits, *namkeem,* noodles, chips, and many more **(Figure 1.6).**

Figure 1.6: Bamboo shoot fortified biscuit and bamboo shoot strews

Bamboo rice

Bamboo rice is a unique type of rice harvested from the seeds of bamboo plants. When bamboo flowers, it produces seeds that resemble rice grains, which are collected, processed, and used as bamboo rice **(Figure 1.7).** Bamboo rice has a unique nutty flavour and is rich in nutrients like protein, fibre, and antioxidants. It is known for its medicinal properties in traditional practices, reputed to help manage diabetes, arthritis, and joint pain.

Figure 1.7: Bamboo rice from seed

(e) Medicinal Uses of Bamboo

All parts of bamboo have been traditionally used for medicinal purposes as recorded in ancient Indian medicine books. Ayurveda, the ancient Indian system of medicine uses *Banslochan* or *Tabasheer* obtained from the bamboo internodes which have a high content of silica good for bones, teeth, and skin. It is also the main ingredient in the Ayurveda medicine *Sitopaladi-churna* that is used for the treatment of various ailments. Bamboo green leaf tea **(Figure 1.8)** is an herbal infusion made from the

young leaves of the bamboo plant, specifically from species like *Phyllostachys* and *Bambusa*. This tea is gaining popularity due to its unique flavour, which is often described as fresh, grassy, and slightly sweet. Rich in antioxidants, bamboo green leaf tea is believed to provide various health benefits, including promoting digestion, enhancing skin health, and boosting the immune system.

Figure 1.8: Bamboo green leaf tea

(f) Bamboo as a Fuel

Charcoal made from this amazing plant has been used for centuries as cooking fuel **(Figure 1.9)**. Bamboo is also used for making briquettes, which are compact blocks of compressed material, often made from organic waste like sawdust, charcoal, or agricultural residues **(Figure 1.10)**.

Figure 1.9: Charcoal

Figure 1.10: Briquette

Ideal for cooking or heating, briquettes are eco-friendly and contribute to waste reduction while providing a convenient energy alternative.

(g) Bamboo Housing

There are three main types of bamboo housing:

(i) Traditional houses: They use bamboo culms as a primary building material **(Figure 1.11)**.

Figure 1.11: A house made of bamboo

(ii) Traditional (barbeque) houses*:* In these houses, a bamboo frame is plastered with cement or clay.

(iii) Modern prefabricated houses: These are made of laminated boards, veneers, and panels. These buildings are usually cheaper than wooden houses. They are light, strong, and earthquake resistant as compared to brick or cement constructions.

(h) Bamboo Panels and Boards

Bamboo panel/board consists of multiple layers of bamboo, available in many variations concerning size, thickness, configuration, style, and colour **(Figure 1.12)**. The use of bamboo panels, laminated bamboo floorings, bamboo veneers, bamboo mats, etc. is rapidly gaining popularity in house construction, furniture, and the handicrafts industry.

Figure 1.12: Bamboo panels

(i) Bamboo Flooring

Bamboo flooring product has certain advantages over wooden floors due to its smoothness, brightness, stability, high resistance, insulation qualities, and flexibility. More and more furniture, flooring, and even homes are being built with bamboo.

(j) Bamboo Fibre

Bamboo clothes are a fabulous trend right now for being used in fabrics and clothing. Bedding made of bamboo fibres is softer than most cotton beddings. They have the look of silk without being expensive. It is becoming a mainstream trend to have bamboo fabric products or clothing, populating many major chain retail stores. Bamboo silk is a product made from a blend of viscose and fibre from the bamboo culm.

(k) Bamboo Jewellery

Jewellery is a product that needs less raw material and tools compared to other crafts. In the training, participants were guided to make jewellery from the Weaved mat using fine slivers, various design mat patterns, Geometric and organic shapes, Quilling techniques and profile cut earrings, chemical and natural dyeing techniques. They also made some bangles using the weaving technique **(Figure 1.13).**

Figure 1.13: Bamboo jewellery

Activities

Activity 1: Participate in a group discussion on the economic, social, environmental, cultural and health benefits of bamboo.

Activity 2: Visit your state bamboo agriculture development agency or state bamboo mission office and note down the information on the products made from bamboo such as furniture, handicrafts, construction, textiles, culinary, biofuel, etc., Also note down the part of plant used in the product. Do not touch the products without the permission of the authority. Do not cause any damage to the products displayed.

Activity 3: Make posters, flyers, and brochures related to various aspects of bamboo.

Activity 4: Visit a local market where bamboo artisans or retailers showcase their bamboo-related products and prepare a note of the products sold by them.

Check Your Progress

A. Multiple Choice Questions

1. What is bamboo also known for_____.

   a) Being the most expensive plant in the world
   b) Being the fastest growing plant in the world
   c) Being the smallest plant in the world
   d) Being the largest plant in the world

2. What is bamboo_____.

   a) A plant
   b) A fruit
   c) A musical instrument
   d) None of the above

3. Technically, bamboo is classified as what type of plant_____.

   a) A Softwood
   b) A Grass
   c) A Hardwood
   d) A Fungus

4. What name is given to the main stalk of a bamboo plant?
   a) Culm
   b) Rhizome
   c) Turion
   d) Sulcus

5.What is bamboo rice?
   a) Rice grown in bamboo fields
   b) Rice harvested from the seeds of bamboo plants
   c) A type of rice used only for making soup
   d) Rice that is high in plastic content

6.What makes bamboo flooring advantageous over traditional wooden flooring?
   a) It is more expensive.
   b) It is less durable.
   c) It is lighter and more stable.
   d) It requires more maintenance.

B. Subjective Questions

1. Describe the socio-economic benefits of bamboo.
2. Explain the environmental benefits of the bamboo plant.

Session 2: Fundamental Parts of Bamboo

Bamboo is a versatile, fast-growing grass known for its strength and sustainability. Additionally, bamboo requires minimal water and pesticides, making it a low-impact option for various industries **(Figure 1.14).**

Figure 1.14: Bamboo culms

This session deals with the morphology, anatomy, and physiology of the bamboo plant. Morphology refers to the outward appearance of the plant's components, anatomy, and the internal structure while physiology refers to its biological function. They are discussed separately.

Morphology: Bamboos are the most diverse group of plants in the grass family, and perhaps one of the most primitive. Bamboos are a few centimetres high, tree-like species rising to up to 30m or more. They are distinguished by having woody culms and complex branching, a complex and generally robust rhizome system, and infrequent

flowering. The main components of a bamboo plant include rhizomes, roots, culms, branches, leaves, and flowers.

1. Rhizome

Rhizomes are underground horizontal stems extending from the main plant that travel underground. It consists of two parts, the rhizome neck and the rhizome proper. The rhizome grows laterally under the soil surface and is branched. It helps the plant to spread its area of growing.

The rhizome consists of nodes from which roots emerge (comes out). Buds come from it and develop into more rhizomes under the ground. On the rhizome, nodes are very close to each other and are protected by sheaths (covering).

There are two broad types of rhizomes in bamboo:

(a) Pachymorph (sympodial rhizome): The pachymorph rhizome system, which is found in clumping bamboos, expands horizontally only by short distances each year. The rhizomes are generally short and thick in appearance **(Figure 1.15).** They curve upwards close to the domain plant. In sympodial rhizome, internodes are broader than long, solid and lateral bud's solitary. At the nodes, new rhizomes or roots can be produced. New culms can only form at the very tip of the rhizome. It is this feature that causes them to curve upwards and exhibit clumping behaviour, for example *Bambusa tulda*. Pachymorph can be classified into two categories, short-necked and long-necked based on the length of the rhizome neck.

Figure 1.15: A clumping rhizome

(b) Leptomorph (monopodial rhizome): The leptomorph rhizome system, found in running bamboos like *Phyllostachys manii*, is characteristic of monopodial bamboo species. These rhizomes extend away from the parent plant, appearing long and thin, with some species capable of spreading up to 20 feet in a single growing season. At the nodes, these rhizomes can form either new shoots (culms) or more rhizomes, leading to a wide distribution. Some bamboo species possess traits of both sympodial and monopodial systems, known as amphipodial rhizomes (**Figure 1.16).**

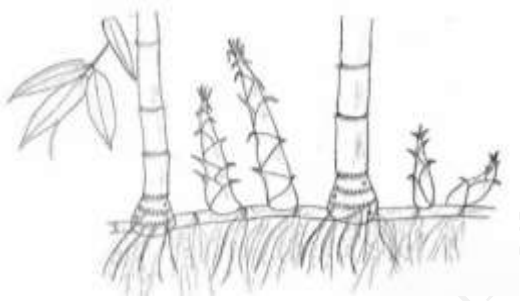

Figure 1.16: A running rhizome

2. Roots – The primary function of roots in bamboo is to anchor the culm to the ground. Without a root system, the culm becomes vulnerable to getting damaged from severe weather. This also allows the culm to hold more weight, giving it the ability to grow more leaves over wider distances. They form at the base of the culm from the rhizome nodes and generally go no deeper than one foot below the surface.

(d) Culms – Culms are the most visibly distinguishable feature of a bamboo plant. The culms are apical in pachymorph rhizome and lateral in leptomorph rhizomes. Culms can vary in size, shape, colour, and even smell. The appearance can range from thick or thin, tall or short, erect or bent, and can exhibit irregular patterns such as those found in Tortoise Shell Bamboo (*Phyllostachys edulis*). Culm sheaths are modified leaves that cover and protect the developing internodes of young shoots and young culms.

Culms may be solid or hollow in the intermodal region. Bamboo with solid culm is known as male bamboo e.g. *Dendrocalamus strictus*.

The colour of the culms also has a wide range of characteristics. Although the majority of bamboos are green, it can also be brown, black, yellow, or striped. One of the most popular garden bamboos, Black Bamboo (*Phyllostachys nigra*), is unique in the fact that the culms exhibit a nearly jet-black colour.

The culms can also vary in smell. One of the most interesting examples is Incense Bamboo (*Phyllostachys atrovaginata*), which has a waxy coat on the culms that emits a pleasant fragrance similar to incense.

New culms generally emerge in the springtime; however, timing varies among species. As the culm shoots from the soil it will have already reached its maximum diameter or girth. The newly emerging culm will grow rapidly and reach its final height by the end of the first growing season. The final size is determined by the local growing conditions, as well as the age and size of the bamboo grove.

(e) Branches – In the majority of the bamboo species, multiple branches grow from a single bud, located at the node. Some genera, such as *Chusquea* (evergreen bamboo) can grow multiple buds from each node (**Figure 1.17).**

Figure 1.17: Bamboo branches

(f) Leaves – Leaves are present at the main portion of each bamboo plant, which includes the rhizomes, culm, and branches.

The anatomy of the leaf itself includes a blade, sheath, and ligule. At first, leaves are present in the rhizome where they are almost completely comprised of the sheath. At this stage, leaves serve as a protective cover to encase the rhizome as it travels underground. After the rhizome shoots through the soil and becomes a culm, the blade becomes the predominant feature.

Figure 1.18: Bamboo leaves

The blade provides the photosynthetic function of the plant by converting sunlight into energy. The appearance of the blade varies among species. In some species, the leaves are very large and less numerous, while other species have a large amount of very small leaves. The appearance of leaves plays a large role in the identification of bamboo. **(Figure 1.18).**

(g) Seeds

Bamboo seeds are variable in size and weight, smaller than the size of a rice kernel to pear-sized fleshy fruits. These seeds are consumed both by animals like rodents, birds, and elephants, and humans. Indigenous people use the seeds as a substitute for rice by boiling it in water just like rice (bamboo rice) and consuming it with curry.

The seeds are also used to make the sweet dish by boiling with milk and jaggery **(Figure 1.19).**

Figure 1.19: Seeds of *Melocanna baccifera* (L) and *Dendrocalamus embranaceous* (R)

Anatomy of Bamboo

Anatomy is the study of the internal structure of a plant. It is frequently investigated at the cellular level and often involves the sectioning of tissues and microscopy.

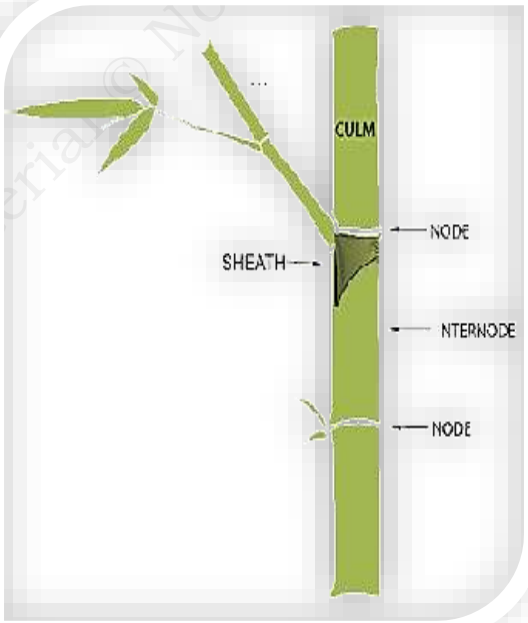

Figure 1.20: Culm Anatomy

(a) Culm anatomy: The gross anatomical structure of a transverse section of any culm internode is determined by the shape, size, arrangement, and number of the vascular bundles. The outer part of the culm is formed by two epidermal cell layers, the inner appearing thicker and highly lignified. The surface of the outermost cells is covered by a cutinized layer with a wax coating. At the peripheral zone of the culm, the vascular bundles are smaller and more numerous, in the inner parts larger and fewer. Monocot stems, do not have a vascular cambium and do not exhibit secondary growth by the production of concentric annual rings. **(Figure 1.20)**

(b) Leaf Anatomy: The various anatomical features observed include: the shape of the leaf blade; structure of midrib; presence or absence of ad axial and abaxial girders of sclerenchyma opposite the vascular bundles; the number of bundle sheaths; presence and arrangement of bull form cells; structure and arrangement

of mesophyll tissue; presence and arrangement of fucoid cells and colourless cells in the mesophyll.

Bamboo Flowering and Seed Production

Bamboo is a monocarpic plant and it's difficult to get the seed. Bamboo seeds have very short viability. In most cases it has to be collected immediately at the time of proper maturity. Therefore, knowledge of the exact time of flowering, seed collection, seed weight, viability, seed handling and nursery techniques is of utmost importance for the success of a plantation programme.

Most of the bamboo species also flower after long intervals of 30-40 years and it is difficult to get seeds when required, so the vegetative method of bamboo propagation is also one of the most important component of nursery techniques.

Among crops, the majority of the annuals is propagated by seeds and requires a nursery for raising the seedlings.

Herbaceous perennials need nurseries for sowing of seeds and planting of cuttings for rooting and establishment. Woody perennials are grown from seeds for multiplying the rootstocks from cuttings, layers and through grafts to perpetuate the same genetic properties.

Bamboo Flowering and Regeneration

The majority of the bamboo species flower after a certain period of years and it again regenerates from seeds but some bamboo species do not produce good seeds like *Schizostachyum polymorphum, S. sesagranium*, etc. They have spikelet flowers with caryopsis fusiform seed.

Bamboos like *Melocana baccifera*, *Schizostachyum arunachalensis* and *Ochlandra travencoria* produce bacca (large fruit). *Dendrocalamus strictus, D. hamiltonii, Schizostachyum pergracile, Bambusa bamboos, Oxythenenthera parvifolia*, etc. have a large compound flower with caryopsis seeds.

Some bamboos like *Schizostachyum capitalism* and *Schizostachyum fuchsianum* produce medium-size seeds and are very delicious food for tribal people and most liked by predators. *Schizostachyum polymorphyum* produces sparsely and round seeds. Almost all the genera are reported to be a flower, however, there is a difference in flowering cycle period on different bamboo species as follows:

1. **Annual or continuous flowering:** The species which flower every year without mortality.

2. **Gregarious or periodic mass flowering:** The whole clump flowers in an extensive area and dies after seed set. The flowering may continue for two to three years in an area or the same clump.

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3. **Sporadic or irregular flowering:** It occurs in isolated clumps (in one or two in an area) or parts of one clump (in one or two clumps), generally with some recovery of the clone or in other cases with complete mortality.

Types of Bamboo Seeds

Bamboo seeds exhibit three distinct types, each with unique characteristics:

a) Caryopsis

- **Description**: A small, dry fruit that remains intact and does not split open at maturity, as can be seen in **Figure 1.21 (i)**.
- **Characteristics**: It has a hard-outer layer for protection, commonly found in grasses, including certain bamboo species.

b) Glans

- **Description**: A small, nut-like seed, often encased in a hard shell, as can be seen in **Figure 1.21 (ii)**.
- **Dispersal**: It can be dispersed by animals or wind.

c) Bacca

- **Description**: Fleshy seeds that develop within a berry-like fruit, as can be seen in **Figure 1.21 (iii).**
- **Characteristics**: These seeds are typically larger than other seed types and may attract animals that assist in their dispersal.

These distinctions highlight the diversity in seed types among bamboo species, which can influence their dispersal mechanisms and germination requirements.

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(i) Caryopsis

(ii) Glans

(iii) Bacca

Figure 1.21: Types of bamboo seeds

Regeneration

There are two types of regeneration in bamboo: Natural and Artificial.

1. Natural Regeneration:

a) **Rhizomes**: Rhizomes are underground stems that grow horizontally. They serve as a critical means of vegetative reproduction for many bamboo species. When conditions are favourable, rhizomes can sprout new shoots, leading to the growth of new bamboo culms (stems). This method allows bamboo to rapidly expand its growth area and establish new colonies.

b) **Coppicing:** Coppicing is a traditional method of managing woody plants by cutting them back to ground level to encourage new growth. In nature, this can happen due to factors like fire, storm damage, or herbivory. When bamboo culms are cut or damaged, the plant responds by producing new shoots from the base or underground rhizomes. This regeneration method is efficient and allows for sustainable growth.

c) **Flowering and Seeding:** Bamboo species typically have a unique flowering cycle, often blooming in intervals of several years (sometimes decades) and producing seeds. After flowering, bamboo plants produce seeds that can be dispersed by wind, water, or animals. This process allows for genetic diversity and the establishment of new bamboo populations in different areas.

2. Artificial Regeneration

a) **Direct sowing:** This method involves planting seeds directly into the soil at the desired location. Seeds are sown at the appropriate depth and spacing, considering the specific species' requirements for moisture and light.

b) **Transplanting seedlings:** This method involves growing bamboo seedlings in a nursery and then transplanting them to the desired location. Seeds are germinated in controlled conditions, and once the seedlings reach a suitable size, they are carefully uprooted and planted in the field.

c) **Vegetative propagation:** This method involves using parts of the bamboo plant (such as rhizomes, culms, or branches) to create new plants. Rhizomes or culm cuttings are taken and planted in suitable conditions to encourage rooting and new shoot development.

d) **Tissue culture**: Tissue culture is a biotechnological method that involves growing plant cells or tissues in a sterile environment on a nutrient medium. Small pieces of bamboo tissue (like shoot tips or nodal segments) are cultured in a controlled environment to produce multiple plantlets.

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Bamboo Species and their Utilization

Out of the 22 genera occurring in India, 19 are native and then 3 are exotic. Out of the 136 species there are a few that are commercially significant. Below are the few significant species of bamboo found in India.

Bambusa bambos

It is a tall, bright-green coloured spiny bamboo species, which grows in thickets consisting of a large number of heavily branched, closely growing culms **(Figure 1.22).** It reaches a height of 10–35 m and grows naturally in the forests of the dry zones.

Figure 1.22 Bambusa bambos

Local names: *Kotoha* (Assam); *Behor* bans (West Bengal); *Mula* (Malayalam); *Kanta* bans (Orissa); *Nal* bans (Punjab); *Saneibo* (Manipur); *Mungil* (Tamil Nadu); *Mulla veduru* (Andhra Pradesh)

Uses: Construction, scaffolding, ladders, Furniture, Paper/Pulp, edible shoots, leaf as fodder

Climatic conditions – Growth is profuse in tropical and tropical to sub-tropical conditions but comes up in dry areas as well.

Bambusa balcooa

Bambusa balcooa **(Figure. 1.23)** is a very large, thick-walled, clumping or sympodial bamboo, growing up to a height of 25 metres, and a thickness of 150 millimetres. It has a 30m tall, dark green culm.

Figure. 1.23 Bambusa balcooa

Local Names: *Baruwa* (Manipur); *Bhaluka* (Arunachal Pradesh, Assam, Bengal); *Beru* (Meghalaya); *Bhalu* bans (Nagaland); Barak (Tripura)

Uses: Scaffolding, construction, ladders, *Agarbatti* sticks, edible shoots, paper.

Climatic conditions- Growth is profuse in tropical and tropical to subtropical conditions. The *Bambusa balcooa* occurs at a height of 600 m. This bamboo can be found mostly in West Bengal and the Northeast region of India.

The most common use of *Bambusa balcooa* is in the construction of houses. It is also used for scaffolding and in ladders**.**

Bambusa nutans

Figure 1.24 ***Bambusa nutans***

Bambusa nutans is an evergreen, clump-forming bamboo with fairly thick-walled, erect, woody stems reaching a height of 6 - 15 metres, with some reports saying they can reach 23 metres. The stems are 4 - 10cm in diameter, with internodes 35 - 45cm long.

Local name: It is also known as Mallo, Malla, Mukia and Badia bansa.

Uses: *Bambusa nutans* is commonly used in house construction and craft activities including the art of basketry.

Climatic Condition: The *Bambusa nutans* grow at an altitude of 500 to 1500m. It grows best on moist hill slopes. It prefers well-drained loamy soil. It can be commonly found in north-eastern regions, Orissa and even Bengal. The culm of this bamboo is smooth, loosely clumped, and has a height of up to 20m **(Figure.1.24).**

Bambusa polymorpha

Figure 1.25: ***Bambusa polymorph***

It is a medium to large size densely tufted bamboo with culms between 15-25 m tall **(Figure 1.25).** Culm internodes are on average 40-60 cm long with 7-15 cm in diameter. The colour of the culms is light green or white grey when young to greyish-green and have relatively thick walls of 1-2 cm.

Local Name: Also known as *Jama betwa, Narangi* bans and Bari.

Uses: *Bambusa polymorph* has many uses. The shoots are edible which are consumed as a vegetable. It is also used in making handicrafts, house construction, and pulping

Climatic conditions: This bamboo can be found in the North East and other regions like Arunachal Pradesh, Meghalaya, and Tripura. The *Bambusa polymorph* likes deep, fertile, and well-drained soil or riverine alluvial soil. The culm can be

either light green or greyish green. Some are even white-grey. The culm is also 25m tall.

***Bambusa tulda* (Indian Timber Bamboo)**

It is a tall, dull green coloured bamboo species with greyish green when mature. It is composed of few closely growing culms. It reaches a height of 6–23 m **(Figure 1.26).**

Figure 1.26: *Bambusa tulda*

Local names: *Jati Bahn* (Assam), *mritinga* (Tripura), spineless Indian bamboo.

Uses: It is used for making *agarbatti* sticks, lumbar, handicrafts, edible shoots, etc. It is used extensively by the paper pulp industry in India.

The shoots of the *Bambusa tulda* are edible.

Dendrocalamus hamiltonii

It is a tall, dull green-coloured bamboo species with drooping tops, which grows in thickets consisting of a few closely growing.

Local name: Commonly known as "Giant Bamboo" in English. In some regions, it may also have local names like "Kans Grass" or "Bamboo Kansa."

Figure 1.27. Dendrocalamus hamiltonii

Uses: In the construction of different materials and also consumed as an edible shoot **(Figure 1.27).**

Climatic conditions: It prefers warm temperatures, ideally between 20°C to 35°C (68°F to 95°F) with a humid environment with annual rainfall between 59 to 118 inches.

It grows best in well-drained, fertile soils, including sandy loam and clay loam, with a pH of 6.0 to 7.5.

***Dendrocalamus strictus* (Male Bamboo)**

It is a tall, dull long green-coloured bamboo species, which grows in thickets consisting of a large number of heavily branched, closely growing culms. It reaches a height of 6–18 m (**Figure 1.28).**

Figure 1.28: *Dendrocalamus strictus*

Local Name: The *Dendrocalamus strictus*, also known as the male bamboo or Calcutta bamboo is native to Southeast Asia.

Uses: They are used for a variety of purposes, mainly including the construction of musical instruments, furniture, rafts, mats, baskets, and household utensils.

Climatic conditions: They are generally found in semi-dry and dry deciduous forests. The culms are 8-20 m tall and are hollow in humid conditions but become solid in dry conditions.

Melocanna baccifera

It is tall, small-culmed bamboo with greenish young culms and straw-coloured old culms. It grows in clumps composed of many well-spaced culms. It has a dense appearance due to its branching habit.

Local name: It is commonly known as "Muli Bamboo" or "Muli" in various regions, especially in Northeast India. It may also be referred to as "Baccate Bamboo" in some contexts.

Figure 1.29 *Melocanna bacciera*

Uses: *Melocanna baccifera* is considered to be a very important source in the production of paper. It is also used in the construction of several things and also the building of houses. The young shoots are very popular as a vegetable in the North Eastern Region (NER).

Climatic conditions: Grown extensively in the North eastern part of the country. It prefers warm temperatures, ideally between 20°C to 30°C and a humid environment with annual rainfall ranging from 1,200 to 2,500 mm. Grows best in well-drained, fertile soils, including alluvial and loamy soils **(Figure 1.29).**

Thyrsostachys oliveri

It is an evergreen, perennial, clumping bamboo with short rhizomes. The erect culms can be 15 - 25 metres long; 50 - 70mm in diameter; with internodes 40 - 60cm long.

Figure 1.30: *Thyrsostachys oliveri*

Local Name: Also known as Oliver's Bamboo.

Uses: The culm of this bamboo is solid in texture and has a height of 7m. It has several uses. It is used in the manufacturing of many products like fishing rods, pole vault poles, and many more.

The shoots of *Thyrsostachys oliveri* are edible. This bamboo has sports-related applications due to its solid texture, flexibility, and other mechanical properties.

Climatic conditions: It prefers warm temperatures, ideally between 20°C to 35°C and a humid environment with annual rainfall of about 1,200 to 2,500 mm. Grows best in well-drained, fertile soils, including loamy and sandy soils with a pH range of 5.5 to 7.0. It prefers full sunlight but can tolerate partial shade, especially during its early growth stage **(Figure 1.30).**

Schizostachyum dullooa

It is an evergreen, perennial, clump-forming bamboo with short rhizomes. The culms, which can be erect, leaning, or scandent, are 6 - 9 metres long; 25 - 75mm in diameter with thin-walled internodes 40 - 75cm long.

Local Name: Also known as *Wadroo* and *Dullooa* in parts of Assam and Meghalaya.

Uses: The culms of this bamboo are used in the production of several things, for instance, mats and baskets. It is also used in the making of small boxes which can be further used for various purposes. The young shoots are edible and are consumed in fermented form also.

Climatic conditions: It is found at an altitude of 1200m and is extensively present in the north-eastern region of the country. The culm of this bamboo does not have a fixed size, although it is smaller as compared to other species. The culm is about 6-9m tall.

Bambusa arundinacea

Bambusa arundinacea bears buds and covered profusely with scales. There is no terminal bud in culm. The height growth is caused by the successive elongation of the internodes. Several internodes from the bottom upwards grow simultaneously.

Local name: It is also commonly known as Giant Thorny Bamboo. In some regions, it may also be referred to as "Kans" or "Bamboo Kansa.

Uses: The leaves are used for many medicinal purposes. They are sweet, astringent, and help deal with constipation. The leaves are also emmenagogue. The young shoots are edible

Climatic location: It grows at an altitude of 2100m and can be found in most parts of India. They can grow up to a height of 40 meters and have linear leaves. The culms are dense and purplish-green when young but later turn golden yellow.

Major Bamboo Producing States/Union Territories in India

The major bamboo-producing states in India are primarily located in the northeastern and southern regions, where the climate and geography are conducive to bamboo growth. More than 50% of the bamboo species occur in the North Eastern region of India- Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, and West Bengal. Other areas rich in bamboo are the Andaman and Nicobar Islands, Chhattisgarh, Madhya Pradesh, and the Western Ghats.

The major bamboo producing states/Union Territories in India include the following:

1. **Assam**: One of the largest bamboo-producing states, Assam is known for its rich bamboo diversity and large bamboo forests.
2. **Tripura**: Tripura is another northeastern state with abundant bamboo resources and extensive use of bamboo in local industries and crafts.
3. **Mizoram**: Mizoram has a significant bamboo cover, and bamboo plays a crucial role in the state's economy.
4. **Arunachal Pradesh**: This state has vast bamboo forests and is a major contributor to bamboo production in the country.
5. **Nagaland**: Nagaland is known for its bamboo-based traditional crafts, Nagaland is a key player in bamboo cultivation.
6. **Manipur**: Bamboo is an integral part of the local economy in Manipur, supporting traditional industries.
7. **Meghalaya**: This state is home to several species of bamboo, contributing to the overall bamboo production in the northeastern region.
8. **Karnataka**: In southern India, Karnataka has significant bamboo resources, particularly in forest areas.

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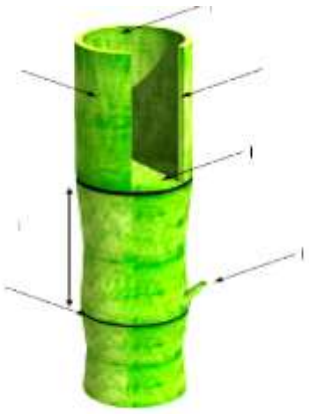
9. **Kerala**: Bamboo is widely cultivated and used in Kerala for furniture, construction, and handicrafts.
10. **Maharashtra**: Maharashtra also contributes to bamboo production, especially in forested areas.

Activities

Activity 1: Visit an agricultural farm to study the morphology of bamboo and identify the various species.

Activity 2: Label the diagram given below



Activity 3: Take photographs of different bamboos. Identify their botanical and common names. You can use a mobile App to identify the species of bamboo.

Check Your Progress

A. Multiple Choice Questions

1.The *Bambusa arundinacea* also known as_____

a) *Bambusa bamboo*
b) Java black bamboo
c) Giant Thorny Bamboo
d) Kanak kai bamboo

2. Which state is known as the bamboo queen of India_____.

a) Mizoram
b) Arunachal Pradesh
c) Madhya Pradesh

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d) Chhattisgarh

3. Which part of the bamboo plant is responsible for its fast growth?

a) Leaves
b) Roots
c) Rhizomes
d) Culms

4.The type of bamboo that spreads through underground rhizomes is known as:

a) Sympodial
b) Monopodial
c) Clumping
d) Grassy

5. The process through which bamboo prevents soil erosion is primarily due to its _____.

a) Long culms
b) Extensive root system
c) Large leaves
d) Fast photosynthesis

6.Which bamboo structure is responsible for storing energy and nutrients for regeneration?

a) Culms
b) Rhizomes
c) Leaves
d) Nodes

7.Monopodial bamboo is commonly referred to as:

a) Running bamboo
b) Clumping bamboo
c) Edible bamboo
d) Decorative bamboo

8. The National Bamboo Mission primarily focuses on which of the following aspects?

a) Bamboo craft
b) Increasing bamboo cultivation
c) Promoting tourism
d) Importing bamboo species

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9.Which bamboo species is commonly used for construction due to its strength?

a) *Bambusa balcooa*
b) *Phyllostachys aurea*
c) *Bambusa vulgaris*
d) None of the above

Subjective Questions

1. Explain the differences between natural and artificial regeneration methods in bamboo cultivation. What are the advantages and disadvantages of each method?

2. Why is bamboo considered one of the fastest-growing plants on Earth?

3. Which bamboo species are best suited for making furniture, and why?

4. How does the *Dendrocalamus strictus* species contribute to India's paper and pulp industry?

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Module 2	Establishing a Bamboo Nursery

Module Overview

Module 1 focuses on the essential practices and techniques required to establish and maintain a successful bamboo nursery. In Session 1, you will learn about the critical factors in site selection and preparation for a bamboo nursery, ensuring optimal growing conditions. Session 2 covers the various methods of bamboo propagation, including seed, cutting, and tissue culture techniques, enabling participants to choose the most suitable approach for their specific context. In Session 3, you will learn about the potting of seedlings and effective nursery operations, guiding learners on how to provide a conducive environment for young plants. Session 4 deals with the care and management of nursery plants, focusing on watering, fertilization, pest control, and other best practices to promote healthy growth. The last Session 5 deals with the post-nursery operations, including transplanting techniques and acclimatization processes, to prepare seedlings for successful establishment in the field.

Learning Outcomes

After completing this module, you will be able to:

- Explain the site preparation for the bamboo nursery.
- Describe the propagation method of bamboo.
- Identify nursery infrastructure, tools, and equipment.
- List the precautions to be taken during the preparation of the nursery bed.
- Discuss care and management of nursery plants.
- Recall the insect, pests and diseases of bamboo in a nursery.

Module Structure

Session 1: Preparations for Bamboo Nursery
Session 2: Propagating Bamboo
Session 3: Preparing Bamboo Nursery Using Seeds
Session 4: Care and Management of Nursery Plants
Session 5: Post Nursery Operations

Session 1: Preparations for Bamboo Nursery

A nursery is a specialized environment for growing and propagating plants from seeds, saplings, or cuttings, providing them with optimal conditions to prepare for field transplanting. The availability of high-quality, true-to-type planting material is essential for successful crop production. Setting up a nursery requires careful planning and expertise and can significantly reduce the time needed to raise the next crop.

Types of Nurseries

(a) Temporary Nurseries: These can be set up with basic, low-cost materials often found locally. Simple shade structures using bamboo or palm are sufficient.

(b) Permanent Nurseries: For long-term or mass propagation, permanent and durable structures are advisable, especially if propagation is intended for 5–10 years or more. A well-accessible site near roads ensures efficient transport and reduces plant stress.

Steps for Establishing a Bamboo Nursery

(a) Phase 1: Planning site layout, clearing land, levelling, gutter and ditch excavation, foundation setting, pathway preparation, and initial utility installation.

(b) Phase 2: Constructing buildings, shade houses, and lath houses.

Key Site Selection Factors

a) **Location**

Choose a site with well-drained soil, adequate sunlight, and protection from strong winds. Proximity to highways or public roads aids in logistics, and closeness to planting areas reduces transport time, stress, and costs.A slight slope (ideally around 5°) helps rainwater run off without erosion. Mid- to lower slopes are preferable, avoiding hilltops or valleys.

b) **Water Supply**

Ensure a reliable, abundant water source. In areas with seasonal water shortages, consider building a storage tank.

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c) **Soil**

Bamboo nurseries thrive in well-drained, fertile soil with a medium-to-light texture, supporting robust growth.

d) **Bamboo Varieties**

Select bamboo species suitable to the climate, soil, and purpose. Fast-growing varieties like *Bambusa vulgaris* and *Phyllostachys edulis* are ideal for commercial production, while ornamental types are suitable for landscaping.

Nursery Layout and Design

a) **Seedling Beds**

Bamboo nurseries typically use beds for seed germination or rooting cuttings in soil. Key conditions like nutrition, moisture, and aeration are vital for seedling growth. Arrange beds in rows with manageable widths (~1 meter) for easy access and airflow.

b) **Shade Areas**

Install shade nets to protect young seedlings, typically requiring 50-70% shade, depending on species.

c) **Water Zones**

Designate watering zones according to species-specific needs to streamline water management.

d) **Walkways**

Ensure clear paths (1–1.5 meters wide) between beds for easy movement and maintenance.

e) **Drainage Ditches**

Small drainage channels around the nursery help prevent waterlogging during heavy rain.

f) **Irrigation System**

A drip or sprinkler system ensures efficient and consistent watering for all plants.

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g) **Storage Room**

A storage room or shed is needed for storing tools, pesticides, and fertilizers. The room should be spacious, well-ventilated, and insulated against moisture and rain.

Tools and Equipment for Nursery Setup

1. **Hand Tools:** These tools are essential for various tasks like digging (shovels, spades), leveling (rakes), soil cultivation (hoes), and transplanting (trowels).

2. **Watering Tools:** Watering cans for precise manual watering, hoses for flexibility, and irrigation systems for efficient, automated watering.

3. **Propagation Equipment:** These include seed trays, pots, and labels to track plant varieties and sowing dates.

4. **Soil Preparation Tools:** Soil test kits to monitor pH and nutrient levels and mixing tools for soil, compost, and fertilizer.

5. **Maintenance Tools:** Weeders for plant care, pruning shears for plant health, and sprayers for fertilizer and pest control applications.

6. **Transportation Tools:** Wheelbarrows, hand trucks, and carts facilitate transporting soil, plants, and equipment.

Fencing and Protection of Nursery

To secure the nursery, various fencing options are available:

1. **Galvanized Iron (GI) Barbed Wire**: Durable and rust-resistant but relatively expensive.

2. **Cattle-Proof Trenches**: Economical option that deters cattle entry without complete fencing.

Inputs for Nursery Operations

1. **Fertilizers and Manures:** NPK (14-14-14 or 15-15-15) fertilizer: It is used by dissolving in water or incorporating it during transplanting. Apply insecticides and decomposed compost one month before planting.

2. **Growth Hormones**

a) **Auxins**: Influence cell enlargement and apical dominance (e.g., IAA, IBA).
b) **Cytokinins**: Promote cell division and senescence.
c) **Gibberellins**: Control shoot elongation (e.g., GA3).

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d) **Ethylene**: Assists in fruit ripening (e.g., ethephon).

3. **Labour:** As nurseries are labour-intensive, readily available workforce is necessary.
4. **Chemicals:** Common chemicals include fertilizers, pH adjusters, and nutrient solutions.

Precautions for Nursery Beds

1. **Soil Quality:** Use well-drained, organic-rich soil for optimal seedling growth, avoiding waterlogged conditions.
2. **Irrigation Management:** Adjust watering based on soil type and avoid excessive irrigation, which can increase disease risks.
3. **Soil Treatment:** Methods like solarization and fumigation can prevent soil-borne pests and pathogens.
4. **Bed Dimensions:** Keep bed width to a maximum of 1 meter and adjust length based on land slope to maintain water distribution.
5. **Shade and Sun Exposure:** Set up beds in areas receiving partial shade to shield delicate seedlings from excessive sunlight and heat.

Activities

Activity 1: Visit a Bamboo Nursery and identify various species of bamboo.

Precautions

- Visit the nursery only with prior approval of the In-charge.
- Do not cause damage to the plants in the nursery.
- Carefully observe the characteristics of the bamboo plant to segregate them into different varieties.

Procedure

1. Contact the nursery In-charge and visit the nursery.
2. Prepare a write-up on different species of bamboo present in the nursery, with their names (common names), and their appearances and segregate them into a reed, shrubs, or straggler forms of bamboo.

Observations

Make note of the following observations during the visit to the nursery.

1. Name and address of the nursery visited.

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2. Name of the bamboo species seen in the nursery.

3. Differences in the characters like height, the diameter of the culm, leaf shape, size, and any other difference that you observed.

4. Group bamboo varieties present there into the herb, shrub, or reed forms.

Check Your Progress

A. Multiple Choice Questions

1. Which of the following is a common method of bamboo propagation in nurseries?

a) Grafting
b) Rhizome division
c) Layering
d) Budding

2. Which soil type is generally preferred for bamboo growth in nurseries?

a) Sandy soil
b) Clay soil
c) Loamy soil
d) Rocky soil

3. What is the ideal spacing for bamboo saplings in a nursery to promote healthy growth?

a) 10 cm
b) 50 cm
c) 1 meter
d) 5 meters

4. Which bamboo species is often preferred in nurseries for its fast-growing characteristics?

a) *Bambusa balcooa*
b) *Dendrocalamus strictus*
c) *Phyllostachys aurea*
d) None of the above

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5. Which hormone is known to influence cell enlargement in plants?

a) Cytokinins
b) Gibberellins
c) Auxins
d) Ethylene

6.What is essential for a nursery's site selection regarding water?

a) A seasonal stream
b) A reliable and abundant water source
c) Proximity to decorative ponds
d) Rainwater collection only

7. Which bamboo species is considered fast-growing and suitable for commercial production?

a) *Phyllostachys edulis*
b) *Bambusa vulgaris*
c) Both A and B
d) None of the above

8. What type of fencing option is described as economical and helps deter cattle?

a) Wooden fencing
b) Chain-link fence
c) Cattle-proof trenches
d) Barbed wire

Subjective Questions

1. What are the essential factors to considered for successful bamboo propagation?

2. What are the key challenges faced in maintaining a bamboo nursery, and how can they be mitigated through proper management practices?

3. How does the spacing of bamboo saplings in a nursery affect their growth and development?

4. What pest and disease management strategies are commonly employed in bamboo nurseries?

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Session 2: Propagating Bamboo

Propagation is the process by which plants are grown from seeds or other plant parts. Bamboos are typically propagated through culms, cuttings, or rhizomes. Bamboo seedlings are raised on nursery beds and then allowed to grow in poly pots for up to a year. Thus, bamboo can be propagated by both sexual (seed-based) and asexual (vegetative) methods, each with distinct advantages and challenges.

Sexual Propagation

a) **Method**: New bamboo plants are grown from seeds. For instance, *Oxtenanthera abyssinica* seeds remain viable for a limited time, typically under ten months, and should be sown in nursery beds soon after collection to ensure successful germination.

b) **Benefits**: Seed propagation allows natural genetic diversity in new plants, which is crucial for adaptability in varied environments.

c) **Limitations**: Seeds have a limited viability period and are only available at certain times due to bamboo's long flowering cycles.

Asexual Propagation

Bamboo is more commonly propagated through vegetative methods, which ensure faster growth and maintain the characteristics of the parent plant.

1. **Rhizome Division**

   a) **Method**: Rhizomes (underground stems) are separated, with each division containing at least one node and some roots.
   b) **Benefits**: This method enables quick establishment, as rhizomes already have a developed root system.

2. **Culm Cuttings**

   a) **Method**: Culms (stems) are cut into segments, generally 30-60 cm long, each with at least one node. These cuttings are planted in prepared soil, either horizontally or vertically.
   b) **Benefits**: Culm cuttings root rapidly and are a simple method for propagating new plants.

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3. **Branch Cuttings**

a) **Method**: Side branches of bamboo, 15-30 cm long, are cut with at least one node per cutting. These are directly planted into the soil.
b) **Benefits**: Suitable for some bamboo species and easy to implement.

4. **Layering**

a) **Method**: A branch is bent and partially buried in the soil, with the tip exposed. The buried section develops roots and establishes a new plant.

- **Ground Layering**: Selected bamboo culms are buried partially to encourage rooting at buried nodes, creating multiple layers from one plant.
- **Stump Layering:** After cutting the stump is covered with soil, keeping the node exposed. The area is kept moist to encourage shoot growth.

b) **Benefits**: The new plant remains connected to the parent, increasing its survival rate until it is well-rooted.

5. **Tissue Culture (Micropropagation)**

a) **Method**: Bamboo tissue is grown in a sterile, controlled environment, resulting in multiple clones of the parent plant.
b) **Benefits**: Mass production of disease-free plants with specific traits of the parent plant is possible through tissue culture.

Propagation Techniques

6. **Runner Propagation**

1-2-year-old runners are selected with viable buds. They are carefully excavated and cut into segments with 3-4 internodes. Rooting hormone is applied at the base, and the runners are planted in nursery beds, and irrigated regularly.

Figure. 2.1: Propagation through runners cutting

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7. **Propagation Through Culm Cuttings**

   a) Use 1-2-year-old culms, cut into 2-3-node sections.
   b) Apply rooting chemicals (IBA or NAA at 200 ppm) to stimulate rooting.
   c) Best for thick-walled bamboo varieties (e.g., *Bambusa balcoa*, *Dendrocalamus asper*).

8. **Branch Cuttings:** Use 1-2-year-old branches with 3-4 internodes. Apply rooting hormones (IBA/NAA) and plant in a sand bed or mist chamber. Suitable for *Bambusa balcoa*, *B. vulgaris*, *D. asper*, and others.

9. **Macro Proliferation:** Separate 5-6-month-old seedlings with prominent rhizomes for propagation. Repeat annually to build a consistent stock of plantable seedlings (**Figure 2.2).**

Figure 2.2: Propagation through a macro proliferation

5. Layering and Macrotting:

a) **Trench Layering**: Bend a one-year-old culm into a trench, covering nodes to encourage rooting.
b) **Macrotting**: Wrap soil-treated nodes in poly bags for root development. Best done in April-May (**Figure 2.3).**

Figure 2.3 Propagation through layering and marcotting

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Advantages and Disadvantages of Propagation Methods

Propagation Type	Advantages	Disadvantages
Vegetative Propagation	• Reduces plantation costs • Ensures genetic consistency	• Labour-intensive • Lacks genetic diversity, potentially increasing disease vulnerability
Seed Propagation	• Simple and affordable • Produces hardy plants with a strong root system	• Limited availability of viable seeds • Higher sensitivity to environmental conditions

Basic Conditions for Successful Bamboo Propagation

a) **Rooting Medium**: Use well-drained, nutrient-rich soil for healthy root growth.
b) **Light**: Provide 6-8 hours of sunlight daily for optimal growth.
c) **Pest and Disease Control**: Apply preventive measures and conduct regular inspections.
d) **Water Management**: Ensure effective drainage to prevent waterlogging.

Seed Treatment and Preparation

a) **Cleaning and Drying**: Collected seeds are thoroughly cleaned and sun-dried for 2-3 hours, then stored in aerated gunny bags.
b) **Storage Conditions**: Maintain humidity at 8-10% and temperature at 10-14°C for optimal storage.
c) **Soaking**: To break dormancy, seeds are soaked in clean water for 10-12 hours, followed by thorough draining 10-20 minutes before sowing.

Sowing in Nursery Beds

Seeds can be sown directly in nursery beds, pots, or polythene bags after treatment.

Selection of Planting Materials

Offset/Rhizome Planting

Select 1-2-year-old culms with active buds and 2-3 internodes, ensuring minimal damage during excavation. Transfer rhizomes to the planting site immediately.

Pit Preparation for Planting

For smaller bamboos (*Bambusa tulda*, *B. pallida*, *Phyllostachys* sp.): Prepare pits of 45x45x45 cm. For larger bamboos (*B. balcooa*, *Dendrocalamus giganteus*): Prepare larger pits (60x60x60 cm).

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Activities

Activity 1: Visit a nearby bamboo farm/plantation or nursery and practice the various methods of bamboo propagation.

Material Required

- Sharp knife
- Root growth hormone

Procedure

1. Enquire and write about the following:

- Different varieties of bamboo present in the nursery.
- Different types of planting materials available at the bamboo nursery.
- The advantages and disadvantages of the different planting materials they use.
- The most preferred planting material according to the nursery owner.
- The difference in the appearances of all the species of bamboo present in the nursery.

Activity 2: Demonstration of selection of rhizome, branches and culms as a source of propagules for vegetative propagation and explain their roles in detail.

Check Your Progress

A. Multiple Choice Questions

1. What is the primary method of sexual propagation in bamboo?

a) Rhizome Division
b) Seed-based propagation
c) Culm Cuttings
d) Layering

2. Which of the following is a benefit of seed propagation?

a) Faster growth
b) Genetic diversity
c) Cloning of plants

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d) Immediate establishment

3. What is a limitation of sexual propagation in bamboo?

a) It requires more space
b) Seeds have limited viability
c) It is labour-intensive
d) It is expensive

4. In rhizome division, each division must contain at least one:

a) Node
b) Leaf
c) Branch
d) Flower

5. Which propagation method involves cutting the culms into segments?

a) Branch Cuttings
b) Layering
c) Culm Cuttings
d) Tissue Culture

6. What is the advantage of using culm cuttings for propagation?

a) Requires less time for establishment
b) Ensures genetic variation
c) Easy to implement
d) Both A and C

7. Ground layering involves:

a) Bending a branch and partially burying it in the soil
b) Cutting the culm into sections
c) Separating rhizomes
d) Soaking seeds in water

8. What is the purpose of using rooting hormones in propagation?

a) To enhance growth speed
b) To stimulate rooting
c) To improve genetic diversity
d) To prevent disease

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9. Which type of propagation method is most labor-intensive?

a) Seed Propagation
b) Asexual Propagation
c) Tissue Culture
d) Macro Proliferation

B. Subjective Questions

1. What is micro-propagation?
2. What is stump layering?
3. Explain the best propagation method for bamboo?

Session 3: Preparing Bamboo Nursery using Seeds

Preparing a bamboo nursery using seeds is a foundational step in establishing a sustainable bamboo plantation. The process begins by selecting high-quality seeds from mature, healthy bamboo plants, as seed quality significantly impacts germination success. Once collected, the seeds should be soaked in clean water for about 24 hours to enhance germination. A well-drained nursery bed, enriched with organic compost, is essential to provide the young bamboo plants with optimal growth conditions. The seeds are sown in shallow rows and lightly covered with soil, and the nursery bed should be regularly watered to maintain consistent moisture.

Seed Collection

Bamboo seeds are collected when bamboo plants flower, which happens infrequently, typically once every few decades. Only healthy seeds from mature bamboo plants should be collected. Viable seeds are usually dark brown, smooth, and plump.

Bamboo seeds are soaked in water for 12-24 hours to soften the seed coat and enhance germination rates. In some cases, seeds may be treated with fungicides to prevent fungal infections or diseases during the germination process.

Sowing in Polythene Tubes or Polybags

Polythene tubes or polybags are commonly used potting containers. Polybags with a size of 40 cm x 50 cm are suitable for small bamboo plants and generally provide sufficient space for the development of roots, rhizomes, and new shoots. If the polybags do not have holes at the base, it is necessary to perforate some holes to provide drainage and thereby prevent the roots from being waterlogged.

The polybag usually is arranged in blocks of rows side by side with the bigger sizes in blocks four-bags wide; the medium and small-sized ones are arranged in 10–12 and 15–17-bag wide blocks.

Nursery Bed Preparation

Bed Dimensions

Prepare raised nursery beds, typically 10 x 1.5 meters, using deep ploughing or digging.

Soil Mixture

The pH of the soil mix must be controlled and brought to an optimum value. At a pH of 5.5, the bamboos assimilate the nutritive elements better and show improved growth. If necessary, the pH of the potting soil mixture can be raised using chemical products such as Calcium carbonate and Calcium sulphate.

Fill the bed with a mix of soil, sand, and fully decomposed farmyard manure (FYM) in a 2:1:1 ratio for optimal nutrition and aeration.

Drenching for Pest Control

Insecticide and Fungicide Application: Drench the bed one week before sowing with insecticide (e.g., aldrin) and fungicide (e.g., bevistin) to protect against termites and fungal infections. Use bio-fungicides like *Trichoderma viride* as an alternative.

Solution Preparation: Apply solutions as specified—40 liters of 0.015% aldrin and 30 liters of 0.05% bevistin per bed.

Sowing

Bamboo seeds are either directly sown in seed trays, beds, or polybags, depending on the scale of operation. Seeds are typically sown at a depth of 1-2 cm and lightly covered with soil or compost.

Perform line sowing at a depth of 2 cm and cover lightly with topsoil. Shade protection using thatch or bamboo split is advised.

Germination Period

Seeds generally germinate within 3-7 days, extending to 15-25 days in cooler climates, or longer for species like *Phyllostachys pubescens* and *Melocanna baccifera*.

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Irrigation

Light daily irrigation keeps the nursery bed moist without waterlogging.

Weeding

Weeds compete with bamboo by absorbing nutrients, water, and sunlight. They often have rhizomes that can regrow if not completely removed. To control weeds, it's important to prepare the soil thoroughly before sowing. Care should also be taken with the sowing media and manure, ensuring they are free of weed seeds. Additionally, removing weeds in the surrounding area is highly recommended to reduce the chances of seed dispersal through wind or water.

The following are recommended practices in weeding:

- Weeding should be done thoroughly, systematically, and regularly.
- When removing weeds from the soil, no portion of the root system should be left behind.
- Weeding should be done only when the soil is moist.
- Weeds that have been removed should be properly disposed of in a rubbish heap.
- Wherever practical and convenient, mechanical weeding tools may be used.

Transplanting

After about 30 days, most of the seeds that are going to sprout with this method. Transplant all of the healthy sprouts into 4cm pots using the next few steps.

Common Issues and Mistakes in Nursery Operations

1. Container and Soil Management

a) **Improperly Filled Containers**: Inadequate filling leads to media settling, which creates air pockets and insufficient water absorption. Ensure containers are filled completely, as this helps in supporting upright growth and provides uniform irrigation.
b) **Inconsistent Container Shapes**: Different container shapes disrupt the uniform space and light distribution essential for growth. Maintaining a consistent, cylindrical shape ensures even light and growth space.
c) **Incorrect Container Positioning**: Bags not placed upright lead to stem curvature. Keep containers aligned and upright to promote straight growth.
d) **Reuse of Soil or Sand in Germination Beds**: Reusing germination media increases fungal infection risks. Changing the medium after each cycle is key to preventing pathogen buildup, like damping-off fungi.

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2. Sowing and Transplanting Errors

a) **Planting Seeds Too Deeply**: Sowing seeds too deep can lead to uneven or low germination rates. Sow at the recommended depth to avoid rain or irrigation washing out seeds.
b) **Poor Seedling Handling During Transplanting**: Lifting seedlings individually or handling them by roots or stems damages delicate roots. Always lift seedlings carefully in groups using a wooden tool, and hold them by foliage for safe handling.
c) **Exposing Seedlings to Air**: Prolonged air exposure, even for more than 10 seconds, causes wilting. Limit air exposure time to prevent transplant shock.
d) **Bad Transplanting Techniques**: Poor root positioning (bent or intertwined) during transplanting hinders growth. Take care to position roots correctly to support healthy seedling establishment.
e) **Air Gaps Around Roots**: Leaving spaces around roots after transplanting limits water and nutrient absorption. Ensure roots have firm contact with the soil to prevent wilting and promote recovery.

4. **Root and Irrigation Practices**

a) **Improper Root Pruning**: Cutting long roots using fingers instead of a sharp knife damages them. Always use a sharp knife to prune roots to avoid squeezing and injury.
b) **Uneven Transplant Bed Levels**: Depressions cause water accumulation, leading to chlorosis and stunted growth. Ensure beds are even to prevent water pooling.
c) **Neglect of Root Pruning Before Field Transport**: Pruning roots ahead of transport reduces shock. Allow adequate recovery time before field planting.

5. Chemical Application

Mixed Chemical Use in Knapsack Sprayers: Using the same sprayer for both weedicides and fungicides risks seedling toxicity. Dedicated sprayers for different chemicals are essential.

6. Hardening Off

Late Hardening Off: Starting hardening off too late leaves seedlings unprepared for field conditions, especially if rains begin. Initiate the process well before transplantation to give seedlings time to acclimate.

7. Handling and Transporting Seedlings

a) **Improper Lifting During Dispatch**: Lifting plants by their stems damages them. Use boxes or crates for safe transport.

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b) **Overcrowding in the Nursery**: Excessive tree shade reduces light availability, attracting pests and hindering the hardening process. Maintain balanced spacing to ensure optimal conditions.

c) **Inadequate Care Near Planting Sites**: Prolonged storage in shaded areas without water leads to rapid deterioration. Transport seedlings with care and provide water promptly to avoid reversing nursery efforts.

Activities

Activity 1: Visit to a bamboo farm**.**

Visit a bamboo farm to identify the different tools, equipment, and materials used for bamboo production.

Activity 2: Preparing potting media.

Material required: Sand, soil, rotten farmyard manure, pot and spade

Procedure

- Collect the required ingredients.
- Measure the volume of sand, soil and farmyard manure (FYM) as per need.
- Mix sand, soil and FYM thoroughly.
- Make a heap of the potting mixture for future use or store the potting media in a shady place away from direct sunlight.

Check Your Progress

A. Multiple Choice Questions

1.Which fungicide is used to keep seeds free rom pathogens:

a) Isocyanate
b) Dung
c) Carbon
d) Thiram

2.At what pH of the soil, bamboo assimilate the nutritive elements better

a) 1.5
b) 2.5
c) 4.5
d) 5.5

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3.Exposure of seedlings to____ for more than 10 seconds causing wilting and delayed seedling growth

a) Chemicals
b) Water
c) Air
d) Alcohol

4.What should be done to ensure proper drainage in polybags?

a) Fill them to the top
b) Use larger sizes
c) Perforate holes at the base
d) Leave them as they are

5.What common mistake involves improper container filling?

a) Overfilling containers
b) Inadequate filling leading to air pockets
c) Using different shapes
d) Placing them incorrectly

6.What should be avoided during the transplanting of bamboo seedlings?
a) Watering before transplanting
b) Lifting seedlings carefully
c) Exposing seedlings to air for too long
d) Ensuring roots are positioned correctly

B. Subjective Questions

1. What is the procedure for raising seedlings in the bamboo nursery?

2. What are the most common mistakes made in nursery operations, and how can these be prevented?

3. Explain how inadequate spacing of plants in a nursery can impact growth and development.

4. What are the environmental factors often overlooked in nursery operations that can lead to plant stress?

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Session 4: Care and Management of Nursery Plants

Effective care and management practices are critical for producing healthy, resilient bamboo seedlings ready for field transplantation. This involves consistent watering, fertilization, pest and disease control, and environmental management, ensuring the development of strong root systems and robust growth. Routine inspections of plant health, root and shoot development, and regular maintenance help build a solid foundation for bamboo plantation success.

Regular Maintenance Practices

a) **Pruning**: If plants remain in the nursery longer than expected, prune them to a height of 40-50 cm with hedge trimmers.
b) **Inventory and Labelling**: Conduct inventories and ensure proper labelling, especially for nurseries cultivating multiple bamboo species.
c) **Cleanliness and Orderliness**: Keep nursery paths, equipment, and tools in good condition and repair them as needed.

Planning and Scheduling Nursery Activities

Proper planning and timely execution are essential for the successful establishment of bamboo seedlings. Following a species-specific nursery activity calendar ensures timely operations and aligns activities with natural seasonal cycles. Key considerations include:

a) **Seed Collection and Sowing**: Collect seeds before they fall and extract them carefully. Sowing should be done during cooler hours, early morning (7-9 am) or evening (3-5 pm).
b) **Scheduled Operations**: Regularly schedule transplanting, watering, weeding, and plant shifting activities.
c) **Hardening Off**: Begin hardening off propagules well in advance to prepare them for field conditions.
d) **Resource Management**: Manage resources like water storage, mother plant maintenance, and seasonal collection of materials efficiently. Stock essential inputs like soil, sand, fertilizers, and bio-fertilizers during cost-effective periods.
e) **Species-Specific Scheduling**: Account for each plant species' seasonal growth cycle to optimize sowing, transplanting, and dispatch timing.

General Nursery Schedule for Seedling Production:

a) Seed collection and extraction
b) Propagule collection
c) Seed sowing and transplanting
d) Seedling dispatch

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Application of Manures and Fertilizers

Generally, bamboo requires fertilizing once or twice a year, with a heavier feeding at the beginning of the growing season and a lighter one in midsummer if needed. Organic fertilizers should be applied earlier as they require more time to integrate into the soil. Liquid fertilizers, which act more quickly, can be applied closer to the shooting season.

a) **Organic Manures**: Well-decomposed compost, cow manure, and other organic matter improve soil structure, moisture retention, and nutrient availability, promoting sustainable growth.
b) **NPK Fertilizers**: For faster results, a balanced NPK fertilizer (e.g., 10-10-10) provides bamboo with essential nutrients like nitrogen for foliage, phosphorus for root health, and potassium for resilience.
c) **Slow-Release Fertilizers**: A granular slow-release fertilizer can also be applied in spring to provide a steady nutrient supply over several months.

Soil Application: Spread fertilizer evenly around the base of each bamboo clump, extending to the drip line. Work it lightly into the soil to maximize absorption. For liquid application, dilute as per manufacturer instructions and apply directly to the root zone. Repeat every 4-6 weeks during the growing season for optimal results. Fertilizer application should ideally be done before the bamboo's shooting season, usually mid to late spring. This timing allows the nutrients to break down and enrich the soil, becoming available by the time bamboo starts its active growth phase.

Shading, and Staking

a) **Shading**: Initial shade is essential for young plants to protect them from direct sunlight and heavy rain. Use thatch or other materials to provide necessary coverage.
b) **Staking**: Provide support for young plants to prevent bending and lodging from wind, rain, or stem weight. Bamboo stakes or branches from other trees (like neem or eucalyptus) are suitable for this purpose.

Pest and Disease Control

Bamboo seedlings in nurseries, plantations, and natural stands are prone to various diseases like rot and blight of emerging culms, foliage blight, rust, etc. Nursery plants are susceptible to various insect pests and diseases. Monitoring and addressing pest infestations early is key to effective control of pests.

Insect Pest/Disease	Characteristics or Symptoms
Aphids	Small green, brown, or black insects; secret honeydew attracting ants and causing sooty mold.

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Thrips	Tiny black or yellow insects affecting young plants and flowers.
Scale	Small, wax-covered insects that infest stems.
Mealybugs	White, filamentous, hair-covered sucking pests.
Mites	Microscopic insects producing webs and galls under leaves.
Leaf Miner	Produces snake-like white lines on leaves.
Termites	Tiny white ants infesting plants underground.
Damping-Off	Fungal infection causing seedling rot (Pythium, Phytophthora, etc.).
Wilt	Discoloration and yellowing of leaves.
Leaf Spot	Black or brown spots on leaves.
Beetles	Damage shoots by chewing.

Rodent Control

Rodents can damage bamboo seedlings by eating shoots and roots. Control methods include traps, poisonous baits, or other local strategies. With thorough care and management, these practices ensure that bamboo nursery plants are healthy, vigorous, and prepared for successful growth in the field.

Activities

Activity 1: Visit to a bamboo nursery.

Visit a nursery for studying the care and management of nursery plants in a bamboo nursery. Observing the activities in the nursery for controlling insect pests and diseases followed by group discussion.

Check Your Progress

A. Multiple Choice Questions

1. Which one of the following practices is to support plants from bending or lodging?
   a) Shading
   b) Pruning
   c) Earthling up
   d) Staking

2. Why is it important to keep the nursery clean and orderly?
   a) To enhance the aesthetic appeal
   b) To facilitate easier access to tools

c) To ensure the health and proper development of the plants
d) To increase the number of plants grown

3. What is the best time to apply fertilizers to bamboo plants?
a) During the winter season
b) Before shooting season, typically mid to late spring
c) Immediately after planting
d) During the rainy season

4. What is the primary purpose of staking bamboo plants?
a) To improve soil quality
b) To support plants and prevent bending or lodging
c) To enhance aesthetic appeal
d) To provide shade

5. Why is it important to engage skilled and trained labour in nursery activities?
a) To reduce costs
b) To assure the success of the nursery activities
c) To increase the number of seedlings
d) To minimize maintenance requirements

6.Which of the following is a sign of leaf miner activity on bamboo leaves?
a) Discoloration
b) Snake-like white lines
c) Black spots
d) Webbing on leaves

7.What is a common method for controlling rodent damage in bamboo nurseries?
a) Using water
b) Neglecting the area
c) Traps and poisonous baits
d) Planting more bamboo

B. Subjective questions-

1. What are nursery care and management practices?

2. What is bio-fertilizer?

3. List the major insect-pests and diseases of bamboo in a nursery.

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Session 5: Post Nursery Operations

Successful post-nursery management is crucial for ensuring that bamboo seedlings are healthy, resilient, and ready for field conditions. This phase includes transitioning plants to greater sunlight, establishing quality standards, careful packaging and transportation, and maintaining meticulous records.

1. **Shade Transition**

In the nursery, potted stock should initially be shaded, with a net cover that has half-centimetre holes. Leaves can be added on top to provide extra shade, with one square meter of coverage for 100 seedlings. After the first month, remove the leaves to allow 30% sunlight. In the second month, increase sunlight exposure to 50-70%, and by the third month, remove the net entirely.

2. **Watering Plants**

During the early stages, water potted stock daily (5 litres per 100 seedlings). As the hardening period approaches, reduce watering to 2-3 times per week.

3. Grading Standards for Planting Stocks

Only high-quality seedlings should be selected for field planting. Key criteria for high-quality seedlings include:

a) Shoot length between one and two times the pot's root length.
b) Strong, woody stem with a well-defined root collar.
c) Dense, asymmetrical crown.
d) Root system with a healthy taproot and many thin roots.
e) No visible signs of fungal or insect damage.

Seedlings that do not meet these standards should be rejected. For varied plantation sites, consider grading into two or three quality classes, using the best plants for challenging or inaccessible areas.

4. Packaging Materials and Precautions

Proper packaging is essential to prevent root drying and mechanical damage during transport. Common materials include hessian cloth, sacking cloth, paddy straw, gunny bags, and plastics (such as LDPE, HDPE, polypropylene, and nylon). Key precautions include:

a) **Root Protection**: Avoid damaging roots when uprooting and packing.
b) **Uniformity**: Plants should be uniform and true to type.
c) **Moisture Retention**: Wrap roots securely to prevent drying during transport.

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d) **Careful Handling**: Inspect plants for pests or diseases before packing.

5. Packaging and Dispatching Procedure

The time between removing seedlings from the nursery and planting them should be minimal. Steps include:

a) **Thorough Watering**: Water plants well before they leave the nursery to maximize their moisture reserves.
b) **Protection from Elements**: Shade plants from intense light, heat, and wind to prevent root desiccation.
c) **Minimizing Handling Damage**: Carefully load and unload plants from vehicles to avoid physical damage.

6. Transportation to the Planting Site

a) **Hardening Off**: Only well-hardened, mature plants are to be transported to increase survival rates.
b) **Root and Stem Quality**: Select plants with well-developed roots and rhizomes, ideally with shorter stems (about 50 cm) but with adequate foliage.
c) **Pre-transport Preparation**: Water thoroughly before transport and handle plants carefully during loading/unloading.
d) **Regular Watering Upon Arrival**: Water the plants immediately upon arrival at the field site until they are planted.

7. Record Maintenance

Maintaining detailed records is vital for tracking nursery operations and assessing methods, costs, and outcomes. Regular record-keeping provides insights for future improvements and budget planning. The following records and notes are to be generally kept for maintenance and understanding the outcomes.

a) **Daily Log**: Records of daily activities, such as watering, fertilizing, pest control, and other maintenance practices are to be maintained.
b) **Technical Notes**: The spacing between bamboo plants will depend on the species to be planted, the primary goal of the plantation, and local soil and climate conditions. Higher densities (closer spacing) are preferable for small sized bamboos, whereas lower densities (more spaced out) are ideal for large sized bamboos.
   Document techniques used, pest infestations, treatments, spacing, watering, and feeding methods.
c) **Seed and Plant Histories**: Information on seed collection, treatment, growth rates, success rates, and quantities of plants are to be maintained.
d) **Time and Labour Tracking**: Record time spent on specific tasks, worker histories, pay records, etc.

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e) **Monthly Reports**: It includes summaries of activities, any issues encountered, and plans for the next month, including explanations for any discrepancies between planned and actual activities.

Activities

Activity 1

Visit the bamboo nursery to discuss the post nursery operations practices. Discuss the following practices:

(i) Grading
(ii) Packaging
(iii) Dispatch
(iv) Transportation

Activity 2

Visit a bamboo plantation and collect information about record maintenance.

Check Your Progress

A. Multiple Choice Questions

1.Which of the following materials can help retain moisture around nursery plants during transport?
a) Hessian cloth
b) Gunny bag
c) Dried grasses
d) All of the above

2.What is the ideal proportion of a seedling's shoot length to its root length (or pot length)?
a) Equal length
b) Less than the root length
c) Between one or two times the length of the root
d) Three times the length of the root

3.What is one benefit of using paddy straw for packing nursery plants?
a) It is waterproof
b) It is biodegradable
c) It is very heavy
d) It provides no insulation

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4.Which of the following is an essential record to maintain for bamboo nursery operations?

a) Marketing strategies
b) Daily log of activities
c) Customer feedback
d) Sales forecasts

5.What is the ideal stem height for bamboo seedlings being transported to increase survival rates?

a) 30 cm
b) 50 cm
c) 70 cm
d) 90 cm

6.What should be done immediately upon arrival at the planting site?

a) Begin planting right away
b) Water the plants immediately
c) Leave them in the shade
d) Prune the plant

7.What is the purpose of shade management in the early stages of bamboo seedling growth?

a) To prevent water loss
b) To transition plants to greater sunlight
c) To enhance root growth
d) To reduce pest infestations

B. Subjective Questions

1. What are the different types of packaging materials used in the nursery?

2. List the things that should be taken care of while transporting the planting material from nursery to plantation site.

3. Explain the grading standards for bamboo planting stocks.

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Module 3	Bamboo Plantation and Management

Module Overview

The Module 3 provides essential knowledge and practical skills for establishing and managing bamboo plantations effectively. In Session 1, you will explore various methods of bamboo plantation, including direct planting and nursery-raised transplanting, assessing the advantages and challenges of each approach to ensure optimal growth. Session 2, focuses on clump management, emphasizing techniques for maintaining healthy bamboo clumps, including thinning, pruning, and ensuring adequate spacing to promote vigorous growth and productivity. In Session 3, you will gain insights into the maintenance and protection of bamboo, covering best practices for pest and disease management, irrigation strategies, and soil health maintenance.

Learning Outcomes

After completing this module, you will be able to:

- Explain the techniques for bamboo plantation and management.
- Describe the process for direct planting of offset cuttings.
- Elucidate the rehabilitation plan for bamboo clumps.
- Explain how to apply fertilizer in the pit of a bamboo plant.
- Identify and describe defective bamboo clumps.
- Prepare a schedule for maintenance and protection activities.
- Demonstrate the knowledge of health and safety practices in the workplace.

Module Structure

Session 1: Establishing a Bamboo Plantation

Session 2: Clump Management of Bamboo

Session 3: Maintenance and Protection of Bamboo

Session 1: Establishing a Bamboo Plantation

A plantation (**Figure 3.1)** is an artificially created forest, farm, or estate specifically designed for the commercial cultivation of crops. This distinguishes it from any ordinary plot of land where plants might grow, as plantations are established with a specific purpose in mind. Bamboo plantations grow well in tropical to warm temperate climatic conditions. A temperature of 16 degrees Celsius is most suitable for the growth of bamboo plants. However, it does not prefer temperatures under 15 degree Celsius in summer. The objective of a plantation is generally to maximize productivity and profit. In some cases, plantations may be established without a primarily commercial purpose but for other purposes of stabilizing soil and its renewal and also reclamation of wasteland.

Figure 3.1: Bamboo Plantation

The main activities involved in establishing a medium or large-scale bamboo plantation are as follows:

1. **Selection of suitable species based on agro-climatic condition:** India has diverse climatic zones. Choose bamboo species suited to your specific region, such as:
   a) **Tropical regions**: Example of species include *Bambusa vulgaris*, *Dendrocalamus strictus*.
   b) **Subtropical regions**: Example of species include *Bambusa balcooa*, *Dendrocalamus giganteus*.

2. Selection of suitable site: Site selection for various species of bamboo is important to enhance management, field operation and healthy growth. The selected area of planting should not be prone to grazing and fire. The planting area should be selected and demarcated early, preferably 2 – 3 months before the onset of rainfall in the year of planting.

3. Preparation of plantation sites: This involves pit digging, clearing the ground, planting bamboo propagules and applying fertilizers, weeding and tending.

Planting and time of Planting

Planting time is the most important phase. The planting should be done during the active growth stage and at the onset of monsoon. There are two planting sessions:

1. **Late winter planting***:* For high altitude or temperate bamboos (January-March)
2. **Early summer planting***:* For tropical to subtropical bamboos (April-June)

Site Selection

Bamboo thrives in loamy and sandy loam soils, but the most important factor is good drainage, as the plant cannot tolerate waterlogging. Well, drained sandy loam to clay loam soils with a pH range of 4.5 to 6.0 are best suitable. Therefore, sloping land is ideal for its growth. Species such as *Dendrocalamus strictus* and *Oxytenanthera abyssinica* are drought resistant and withstand areas having an annual rainfall of less than 800 mm. For reasonably good growth, most bamboos require annual rainfall of more than 1000 mm.

Site Preparation

The preparation of the plantation site should only begin after plantation layout has been planned and defined. The planting site must be cleared of bush, grass and other unwanted vegetation. Clean cultivation may also be carried out especially where intercropping of bamboo with other crop is to be done. The gestation time of a bamboo plantation is 5 years, so the interspace can be used for extra income during the first 3 years by planting intercrops such as ginger, chillies or any shade-loving aromatic/medicinal plants.

After ground clearing, planting pits are dug at spacing suitable for the species to be planted, following the plantation layout and design. The size of the planting pit will depend on the type of planting material as well as on the rainfall and climatic conditions of the planting site. A larger and deeper planting pit is always better and allows for the easier establishment of newly planted bamboos.

Usually, pit sizes of 60 cm diameter and 60 cm depth should be dug around each stake in areas of medium to high rainfall. Well-rooted seedlings or TC bamboos may be planted in a small pit of 30 cm diameter and 30 cm depth.

A wider planting pit of up to 1 meter in diameter allows for improved micro catchment and is preferred in areas where annual rainfall is less than 1000 mm. In all cases, the pit must be refilled with soil up to 10 cm below the ground surface where necessary mix up to 2 kg organic manure or the topsoil of each pit must be there. The filling should be completed one month before the rainy season.

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Direct Planting of offset cuttings / Rhizome: Direct planting of offsets of bamboo in the plantation area may be done in small plots or homestead farms. Planting should be conducted at the beginning of the rainy season. The selection and preparation of offset cutting for direct planting follows the same procedure as that of planting stock for nursery-raised cuttings except that cuttings are directly planted in the field pits without poly potting **(Figure 3.2).**

The procedure for direct planting is as follows:

- Transport the offset cuttings to the planting location.
- Loosen the soil in previously prepared planting pits/holes.
- Place the cuttings in the pit in a vertical position. The lowest node of the culm offset should be above the ground.
- Water the soil thoroughly and mulch around the planting pit.
- If necessary, offsets should be protected against termite attacks. The soil placed in the planting pit should be mixed with an anti-termite chemical.

Figure 3.2: Direct planting of offsets of bamboo

Preparation of Bunds and Trenches

The trench cum bund method of spacing involves planting bamboo on 1-meter-wide and 50 cm high bunds (heap of soil). The bunds are prepared by digging trenches and heaping the dug-out soil. The distance from the centre of one bund to that of the next on a 5 × 5-meter plantation should be 5 meters. The method facilitates mounding as the plants grow. The trenches can be used for irrigation, or for preparing *vermicompost.*

Preparation of Pit Size

After clearing the land and digging the pits, the bamboo plantation area should be measured and marked with sticks from the point that will be the centre of the pit. The pit should be wide and deep enough to ensure that the roots of the bamboo plants have sufficient space and are not restrained in their search for moisture and nutrients. It is best to prepare the pits before the rainy season and the dugout soil exposed to weather conditions.

As a thumb rule: the larger the pit, the better the growth of the rhizomes. Offsets and rhizomes should be planted in pits measuring 60 x 60 x 60 to 100 x 100 x 100 centimetres. For seedlings and branch cuttings, the size can be reduced to 30 x 30 x 30 or 45 x 45 x 45 centimetres.

Bamboo Planting in Pits

- A few days before planting, thoroughly turn the soil in the pit.
- Remove competing weeds and vegetation within a radius of 50 centimetres around the pit.
- For a pit size of 60 x 60 x 60 centimetres, mix the soil with approximately 5 kilograms of farmyard manure (FYM), 100 grams' urea, 100 grams' superphosphate and 50 grams muriate of potash. Nitrogen in the ammonium form increases water uptake, resulting in faster growth.
- Place the plant vertically in the pit, ensuring that the roots do not curl.
- Level the pit with the mixed and enriched soil.
- After planting, irrigate the plant, depending on the current climatic conditions. This will provide the needed moisture to the rhizome and roots and compress the loose soil around the plant.
- Repeat the watering in the next day, moderating the quantity of water if necessary. For the next 10 weeks, continue to irrigate if there is not enough rain, initially at daily intervals, extending later to once in three days.

Spacing

- **Between Pits:** Bamboo plants should be spaced between 2 to 5 meters apart, depending on the species and their intended use (such as for timber or as a screen).
- **Considerations:** It's important to maintain adequate spacing to promote healthy growth and air circulation while reducing competition for nutrients and water.

Depth

- **Pit Depth:** Pits should be dug to a depth of 30-45 cm to comfortably accommodate the root systems and ensure proper drainage.
- **Soil Quality:** If the soil is hard or compacted, consider digging deeper or loosening the soil at the bottom to enhance root development.

Time and Spacing for Plants Raised in the Nursery

Best Time for Planting:

a) **Spring Season**: The ideal time for planting bamboo in nurseries is from **March to April**, just before the onset of the monsoon. This timing allows the plants to establish themselves with the upcoming rainfall.

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b) **Monsoon Season**: June to July is also a suitable time for planting, as the monsoon provides adequate moisture for the young plants.

Spacing

a) **Between Plants**: Space bamboo plants approximately 1 to 2 feet (30 to 60 cm) apart within rows. This allows enough room for growth and reduces competition.
b) **Between Rows**: Leave a distance of about 2 to 3 feet (60 to 90 cm) between rows to facilitate maintenance and access.

Transplanting Period

Bamboo seedlings are generally ready for transplanting when they reach about 6 months to 1 year old, depending on the specific species and growing conditions.

a) **Between Plants:** When transplanting, keep a spacing of 2 to 5 meters between individual bamboo plants, which varies based on the species and intended use (such as for timber or screening).
b) **Row Spacing:** If planting in rows, ensure there is adequate space between rows to facilitate maintenance and prevent overcrowding.

Manure and Fertilizers

Key nutrients like potassium and nitrogen are vital for promoting healthy growth and development in bamboo plants. Additionally, green manures, organic compost, wood ash, and chemical fertilizers should be incorporated to support plant health.

(i) Farm Yard Manure: Farmyard manure consists of decomposed materials including the dung and urine of farm animals, mixed with litter and remnants of fodder. It is rich in organic matter, it provides essential nutrients and enhances soil structure. A well-composted farm yard manure is mixed into the soil a few weeks prior to planting, using a rate of 5-10 tons per hectare.

(ii) Vermicomposting: Vermicompost, a high-quality, nutrient-rich organic fertilizer, significantly enhances the soil's physical and chemical properties. Its application improves soil health and adds beneficial inputs for bamboo cultivation.

(iii) Neem Cake: Neem cake functions as a natural pesticide while supplying nitrogen. It is incorporated into the soil at a rate of 100-200 kg per hectare, ideally before planting, to support healthy growth and ward off pests.

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Irrigation Management

Bamboo grows best when there is adequate moisture in the soil. During initial years of a plantation, the young plants need extra care and water. Lack of moisture in the soil badly affects the growth of rhizomes and the culms. Irrigation of the plantation reduces mortality in young plants and improves the health and productivity of bamboo clumps.

The requirement of irrigation will vary with the local climatic conditions and the soil type. Various irrigation methods can be used. The type of irrigation to be used will be determined by the actual moisture in the soil, especially in the growing season.

a) **Channel irrigation:** It is recommended in the dry season. It should be done at least once a week.
b) **Drip irrigation:** In an area where water is less, drip irrigation should be used. However, it is found to be cost-effective.
c) **Wick method of irrigation**: The method of irrigation using the traditional 'earthen pitcher with a wick' is an effective and uses water frugally (simple and not cost too much). A 2-liter pitcher would require refilling thrice a week.

Intercultural Operations

a) **Weeding** is the process of removing unwanted plants from the plantation area. In the initial years of the plantation, regular weeding is necessary to prevent weeds and other vegetation from competing with the young bamboo for resources like sunlight, nutrient from the soil and space. Intensive weeding is required at least for the first 2 years after the rains and towards the end of the wet season.

b) **Cleaning** is carried out in a crop that has not crossed the sapling stage and is defined as the cutting made to face the best individuals from undesirable one of the same age which interfere or are likely to interfere with the growth of the desired individuals.

c) **Pruning** is the process of cutting the tips of the branches. In some species of bamboo, there is heavy branching at the lower nodes of the plant. Pruning of these branches reduces clump congestion and helps provide a healthy, airy environment within the clump. Mild pruning should be undertaken in the second and third years of growth and intensive pruning from the fourth year onwards. It should be completed before the end of the dormancy period (winter months when the growth is very less) well before the shoots emerge.

d) **Thinning** is the removal of bamboo culms or shoots to avoid over-dense clumps. This can be done either by removing young newly emerging shoots or you can also choose mature culms to be cut down to maintain your clump at the desired density. Thinning the clump is essential from the third year onwards to avoid crowding and to ensure proper growth and easy harvesting of culms. Weak and deformed culms should not be kept in the clump. An appropriate clump structure should be maintained through thinning as well as through extraction/retention of shoots.

e) Harvesting of bamboo can be done in the 5th year, but it is best harvested in the sixth year in commercial farming. In the 6th year, 6 culms/clump can be harvested followed by 7 culms in the 7th year, 8 culms in the 8th year, and 9 culms from the 9th year onwards. Generally, the 1 or 2-year-old culms are left for regeneration.

Harvesting bamboo for timber and edible shoots requires careful, sustainable practices to ensure continuous growth and high-quality yields.

Harvesting Bamboo for Timber Production

a) **Seasonal Timing**: Harvest during the dry season, which minimizes moisture in culms and reduces fungal risks. If the clump is congested, some selective thinning may be done outside this period.

b) **Selective Harvesting**: Avoid clear felling, which damages clump structure and can lead to bushy, less productive regrowth. Only harvest mature culms (at least 3 years old) to ensure sustainable yield and prevent stunting.

c) **Retention for Growth**: Retain all current-year culms to ensure the next growth cycle. Keep a mix of mature and older culms to protect new culms and maintain the clump's microenvironment. Maintain a minimum of six culms over one-year-old, evenly spaced within the clump for structural integrity and to allow light and airflow.

d) **Yield Management**: The number of culms harvested should not exceed the number of new culms from the previous year, ensuring a balanced growth cycle.

e) **Felling Technique**: Examine each clump carefully, selecting culms based on maturity and position. Cut culms as low as possible, leaving only one internode above the ground. Use a sharp saw or knife to avoid splitting, ensuring clean cuts for optimal regrowth. Remove all debris, dead, and dry bamboo, as well as high cuts or damaged culms to maintain a healthy clump structure.

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f) **Harvesting Bamboo for Edible Shoots:** Harvest shoots when they are 15–50 cm tall (species-dependent) for the best texture and taste. Carefully clear soil around the shoot without damaging the mother rhizome, using a clean, sharp knife for precise cuts. Avoid diseased or deformed shoots. Retain a few of the strongest shoots during peak growth to develop into mature bamboo for future cycles. Harvest shoots from various points in the clump rather than a single area to prevent congestion and allow even clump growth.

Activities

Activity 1: Visit to local bamboo plantations.

Visit the local bamboo plantations and observe mature bamboo plants and learn about sustainable farming practices, propagation methods, and bamboo's commercial uses.

Activity 2: Campaigning to raise awareness about the importance of bamboo.

Create posters, brochures, or social media content highlighting bamboo's ecological benefits, uses, and the need for sustainable practices.

Check Your Progress

A. Multiple Choice Questions

1. Which bamboo species is suitable for tropical regions?

a) *Dendrocalamus giganteus*
b) *Bambusa vulgaris*
c) *Oxytenanthera abyssinica*
d) *Bambusa balcooa*

2. What is the ideal planting pit size for medium to high rainfall areas?

a) 30 cm x 30 cm
b) 45 cm x 45 cm
c) 60 cm x 60 cm
d) 100 cm x 100 cm

3. Which method is used to enhance irrigation in bamboo plantations?

a) Channel irrigation
b) Surface flooding
c) Overhead sprinkling
d) None of the above

4. What type of fertilizer is recommended for bamboo plants before planting?

a) Only chemical fertilizers
b) Farmyard manure
c) Only organic compost
d) No fertilizers are needed

5. How often should young bamboo plants be irrigated during the initial years?

a) Once a month
b) At least once a week
c) Twice a year
d) Only during the rainy season

6. What is the main purpose of weeding in a bamboo plantation?

a) To enhance aesthetic value
b) To prevent competition for resources
c) To attract beneficial insects
d) To increase soil temperature

7. When should bamboo be harvested for the best timber production?

a) In the second year
b) In the sixth year
c) In the fourth year
d) In the eighth year

8. Which of the following practices should be avoided during bamboo harvesting?

a) Selective harvesting of mature culms
b) Clear felling of the entire clump
c) Retaining some older culms
d) Cutting as low as possible to the ground

B. Subjective Questions-

1. Describe the role of pits in the bamboo plantation.
2. Explain considerations for a good bamboo plantation
3. Explain the gap-filling method in bamboo?
4. What do you understand by early tending?

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Session 2: Clump Management of Bamboo

Clump management in bamboo is essential for maintaining plant health, maximizing productivity, and ensuring sustainable yields. Effective clump management involves regular thinning, pruning, and selective harvesting. Removing older, dead, or damaged culms promotes the growth of younger shoots and prevents clump congestion, which can otherwise lead to poor air circulation and increased susceptibility to pests and diseases. Periodic clearing of debris, dry bamboo, and excessive soil accumulation around the base further improves clump health and encourages robust shoot emergence. By practicing these methods, clumps can remain productive over multiple growth cycles, balancing ecological sustainability with economic yield.

1. Clump Rehabilitation

Clump rehabilitation is the process of restoring and enhancing the productivity of bamboo clumps that are overgrown or poorly managed. This involves strategic thinning, pruning, and removing dead or damaged culms (bamboo stems) to encourage healthier growth and ensure the vitality of the bamboo clump. These practices help improve overall yield and quality, creating a sustainable and productive plantation. Through effective rehabilitation, bamboo farmers can secure a consistent harvest while preserving the health of the plantation in the long term.

2. Sanitation Cutting

Sanitation cutting refers to the removal of injured or dead bamboo culms, particularly those affected by fire, wind, or disease. This practice prevents the spread of disease and insect infestations, both of which can devastate bamboo stands if not controlled. Field sanitation involves removing and destroying diseased plant material, pests, and weeds that threaten the plantation's health. By removing these harmful elements, farmers can significantly reduce the risk of pest and disease outbreaks, thereby protecting the long-term vitality of the clump.

3. Management of Defective Culms

The effective management of defective bamboo culms is crucial in previously unmanaged or rehabilitated clumps. Some common defective culms include:

a) **Broken Culms**: Often caused by wind or mishandling, broken culms can hinder growth and create openings for pests and diseases.

b) **Dead or Dying Culms**: Dead culms are typically dry and brittle and lack green tissue. They compete for resources with healthy culms, which weakens the clump overall.

c) **Crooked Culms**: These culms grow at an angle or have irregular shapes, often due to competition for sunlight or poor soil conditions, making them less valuable for timber and structurally weaker.

d) **Stunted Culms**: These culms have limited growth and remain shorter and thinner than healthy culms due to nutrient deficiencies or inadequate water.

e) **Diseased Culms**: Signs of disease may include discoloration, wilting, or fungal growth. Diseased culms can spread infections to healthy plants, making it essential to remove them promptly to prevent widespread issues within the clump.

4. Removal of Dead and Decayed Culms

To maintain clump health, dead and decayed culms, as well as any excess branches, should be promptly removed. This process allows for the development of higher-quality culms and makes space for new shoots to emerge. By pruning and thinning dead material, bamboo clumps are better positioned to produce strong, healthy growth, which is especially important for areas with high productivity goals.

5. Disease Management

While bamboo naturally hosts a variety of fungi, microorganisms, and insects, certain species can be detrimental. Diseased culms, especially those colonized by fungus, infested by insects, or attacked by parasites, should be immediately removed and, if possible, the affected areas burned. This practice limits the spread of infections to other clumps, preventing widespread disease within the plantation.

6. Safety Practices in Clump Rehabilitation

Safety is paramount in bamboo clump rehabilitation, especially when restoring degraded areas in forests. Essential practices include:

a) **Site Assessment**: Conduct a thorough assessment to identify risks such as unstable ground, hazardous wildlife, or harmful plants before starting work.

b) **Personal Protective Equipment (PPE)**: Workers should wear gloves, boots, helmets, and eye protection to minimize injury risks.

c) **Safe Tool and Chemical Handling**: Proper training in operating chainsaws, digging tools, and handling chemicals like herbicides or pesticides is essential. Chemicals must be used, stored, and disposed of according to guidelines.

d) **Erosion Control**: Especially on slopes, erosion control is necessary to prevent landslides, and work should be paused during extreme weather.

e) **First Aid and Emergency Protocols**: First aid kits should be available, with at least one trained responder on-site to handle cuts, bites, or stings. Fire safety protocols are essential, especially if controlled burns are part of the rehabilitation. Effective communication, a buddy system, and clear emergency protocols should be in place to handle isolated incidents efficiently.

Activities

Activity 1: Visit to a bamboo plantation

Visit a bamboo plantation to study the rehabilitation plan and procedures adopted by the farmers. Conduct a clump assessment of existing bamboo. Take notes on the following:

(i) Health of bamboo clumps
(ii) Growth density
(iii) Age of culms
(iv) Signs of pests or disease

Based on the observations, you can record your findings regarding clump management and discuss necessary management actions.

Check Your Progress

A. Multiple Choice Questions

1. How soon after planting should chemical fertilizer be reapplied?

a) Within 1-2 weeks
b) Within 1-2 months
c) Within 3-4 months
d) Within 6 months

2. Which of the following indicates a bamboo culm that should be removed?

a) A culm that is dry
b) A culm with visible fungus
c) A culm that is producing new shoots
d) A culm that is taller than others

3. What is the primary goal of clump rehabilitation?

a) To increase the number of workers
b) To restore degraded vegetation areas
c) To enhance wildlife tourism
d) To clear areas for agriculture

4. What is one benefit of bamboo plantations in rehabilitating degraded lands?

a) Increased soil erosion
b) Soil restoration and stabilization
c) Decreased biodiversity
d) Higher carbon emissions

5.What is a common characteristic of defective culms?

a) They are always taller than healthy culms
b) They may hinder growth and attract pests
c) They grow in clusters
d) They do not require water

6.Which practice helps prevent the spread of diseases in bamboo clumps?

a) Increasing the density of culms
b) Removing diseased culms immediately
c) Ignoring minor infections
d) Watering more frequently

7. What is an essential safety practice during clump rehabilitation?

a) Site assessment to identify risks
b) Working without protective equipment
c) Using tools without training
d) Ignoring weather conditions

B. Subjective Questions

1. What are the key characteristics of a healthy bamboo clump?

2. Explain the importance of regular pruning in bamboo clump management.

3. What challenges are faced in bamboo cultivation and management?

4. How can these factors, such as light, moisture, and temperature be optimized for better growth of bamboo?

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Session 3: Maintenance and Protection of Bamboo

In the first two years after planting, maintenance activities should primarily aim to protect young bamboo plants from competition with other vegetation and pest damage. After the second year, maintenance shifts to managing the bamboo clumps for optimal productivity.

Schedule of Maintenance Activities

1. **Soil Loosening:** In the first year, the soil is gently loosened around each bamboo plant to improve aeration, enhancing growth. The soil is loosened twice a year and care is to be taken not to disturb the rhizomes (root system) beneath the surface.

2. **Weed Control:** Weeds and competing vegetation hinder bamboo growth. Weeds should be cleared within a 60 cm radius around each clump to support healthy culm (stem) development.

3. **Pest and Grazing Control:** Bamboo leaves and shoots are attractive to animals, especially in dry seasons. For small areas, fencing can be a practical solution, though larger plantations may require regular monitoring to control animal access. Check regularly for damage, investigate causes, and implement appropriate solutions to prevent grazing.

4. **Mulching:** Applying mulch, especially in drier areas, conserves soil moisture, prevents weed growth, and adds organic nutrients. A layer of organic material is spread around each clump to protect young shoots from direct sunlight, keeping them moist for optimal growth. Leaf litter can be used as a mulch, as it is easily available. Mulching retains soil moisture as well as controls the growth of weeds. All transplanted plants should be mulched with straw or hay at a depth of 20 cm and a diameter of 2 m.

5. **Clump Maintenance:** Regular maintenance of bamboo clumps not only boosts productivity but also simplifies the work for plantation laborers. Unwanted culms are removed to prevent congestion, especially in dense species like *Oxytenanthera abyssinica*. Since new shoots typically grow at the outer edges of the clump, maintain older culms in the interior and younger culms on the periphery for sustained growth.

6. **Termite Prevention:** Termites target old, decayed, or damaged bamboo. Prevent infestations by removing rotting culms and maintaining overall clump health, which minimizes termite risks.

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7. **Fire Prevention:** Bush fires are a significant risk, particularly in dry seasons. Prevent fire spread by mulching dry leaf litter around clumps and establishing firebreaks, which are cleared sections (10-15 meters wide) around the plantation.

Workplace Safety Precautions for Bamboo Field Workers

Fieldwork in bamboo plantations requires adherence to strict safety practices to minimize health risks and accidents. Key precautions include:

a) **First Aid**: Have first-aid kit and supplies readily available.
b) **Protective Gear**: Workers should wear tight-fitting clothing, tie back hair, and use gloves, goggles, and footwear when handling pesticides or using machinery.
c) **Chemical Safety**: Follow all safety protocols for pesticide use, including safe disposal of chemicals, handling with care, and using proper protective gear.
d) **Safety Zones**: Designate areas for chemical treatment as no-smoking zones, and prevent food or drink consumption in these areas to avoid contamination.
e) **Post-Work Hygiene**: After handling chemicals, wash thoroughly with soap, take a shower, and change work clothes to reduce chemical exposure.

Farm Maintenance and Protection Practices

Long-term farm productivity requires careful maintenance, sustainable practices, and safety measures, outlined below:

1. **Soil Health and Conservation**

a) **Soil Testing**: Regularly test for pH, nutrient levels, and organic content.
b) **Crop Rotation**: Rotate crops to maintain soil health and reduce pest build up.
c) **Organic Matter**: Add compost or manure to enhance soil structure.
d) **Erosion Control**: Use cover crops, contour ploughing, and terracing.

2. **Water Management**

a) **Irrigation**: Inspect systems regularly and consider drip irrigation for efficiency.
b) **Rainwater Harvesting**: Implement collection systems to reduce reliance on external water.
c) **Conservation**: Use mulching and water-efficient practices to minimize evaporation.

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3. **Livestock Care and Management**

   a) **Shelter Maintenance**: Keep animal shelters clean and ventilated.
   b) **Health Checks**: Schedule regular veterinary visits and vaccinations.
   c) **Fencing**: Secure fencing to prevent livestock wandering.

4. **Pest and Disease Management**

   a) **Integrated Pest Management (IPM)**: Use crop rotation, biological controls, and limited chemical use.
   b) **Disease Monitoring**: Check plants and livestock for signs of disease.
   c) **Sanitation**: Maintain cleanliness in animal housing and storage areas.

5. **Farm Equipment Maintenance**

   a) **Inspections and Repairs**: Regularly inspect equipment and follow service schedules.
   b) **Storage**: Protect equipment from the elements.

6. **Sustainable Farming Practices**

   a) **Organic Farming**: Avoid synthetic chemicals, supporting soil and biodiversity.
   b) **Agroforestry**: Plant trees to promote biodiversity and prevent erosion.
   c) **Energy Efficiency**: Use renewable energy options like solar power.

7. **Farm Security**

   a) **Fencing and Gates**: Secure boundaries to protect assets.
   b) **Surveillance**: Install cameras or sensors in key areas.
   c) **Lighting**: Illuminate storage areas for added security.

8. **Record-keeping and Financial Management**

   a) **Records**: Document crop yields, livestock health, and finances.
   b) **Budgeting**: Allocate funds for maintenance, repairs, and emergencies.

9. **Farm Safety**

   a) **Worker Training**: Train all workers in safe practices and provide Personal Protective Equipment.
   b) **Emergency Plans**: Establish protocols for incidents like fires or accidents.

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10. **Biodiversity and Wildlife Protection**

a) **Habitat Creation**: Preserve natural areas for wildlife.
b) **Sustainable Land Use**: Avoid over-farming to maintain ecosystem health.

Activities

Activity 1: Collect pictures or examples of pests, and discuss the strategies for managing the pests of bamboos. Include the use of natural repellents in your discussion.

Activity 2: Demonstrate the procedure of maintaining the bamboo plantation.

Check Your Progress

A. Multiple Choice Questions

1.What should be done to reduce the risk of termite infestations in bamboo?
a) Leave all culms in place
b) Extract old and rotting culms
c) Increase the density of culms
d) Water the bamboo more frequently

2.Why is mulching necessary for the production of good-quality bamboo shoots?
a) It allows them to grow to an optimal size without hardening
b) It makes them more resistant to diseases
c) It encourages larger leaf production
d) It reduces the need for fertilization

3.What effect does agroforestry have on soil health?
a) It depletes nutrients
b) It improves soil structure and fertility
c) It has no impact on soil health
d) It leads to increased erosion

4.How does organic farming support biodiversity?
a) By using chemical pesticides
b) By promoting a variety of crops and natural habitats
c) By limiting crop rotation
d) By reducing the number of plant species

5.Which practice helps prevent termite infestations in bamboo clumps?
a) Increasing watering frequency
b) Removing rotting culms and maintaining clump health
c) Adding more mulch
d) Pruning only younger culms

6.What should be done to prevent bush fires in bamboo plantations?
a) Increase plant density
b) Establish firebreaks and mulch dry leaf litter
c) Water the plantation more frequently
d) Use chemical fire retardants

7.What is a key safety practice for workers handling pesticides?
a) Using protective gear like gloves and goggles
b) Working without supervision
c) Consuming food in chemical treatment areas
d) Ignoring first aid protocols

8.Which of the following is a sustainable farming practice?
a) Using synthetic fertilizers
b) Implementing agroforestry
c) Ignoring soil health
d) Over-farming land

B. Subjective Questions

1. What is First Aid?
2. What is occupational safety?
3. What strategies can be adopted for generating safety awareness in the workplace?

Answer Key

MODULE 1: INTRODUCTION TO BAMBOO

Session 1: Bamboo and Its Benefits

A. Multiple Choice Questions

1. b
2. a
3. b
4. a
5. b
6. c

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Session 2: Fundamental Parts of Bamboo

A. Multiple Choice Questions

1. c
2. a
3. c
4. a
5. b
6. b
7. a
8. b
9. d

MODULE 2: ESTABLISHING A BAMBOO NURSERY

Session 1: Preparation for Bamboo Nursery

A. Multiple Choice Questions

1. b
2. c
3. c
4. c
5. b
6. b
7. c
8. c

Session 2: Propagating Bamboo

A. Multiple Choice Questions

1. b
2. b
3. b
4. a
5. c
6. d
7. a
8. b
9. b

Session 3: Preparing Bamboo Nursery Using Seeds

A. Multiple Choice Questions

1. d
2. d
3. c

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4. c
5. b
6. c

Session 4: Care and Management of Nursery Plants

A. Multiple Choice Questions

1. d
2. c
3. b
4. b
5. b
6. b
7. c

Session: 5 Post Nursery Operations

A**. Multiple Choice Questions**

1. d
2. c
3. b
4. b
5. b
6. b
7. b

MODULE 3: BAMBOO PLANTATION AND MANAGEMENT

Session 1: Establishing a Bamboo Plantation

A. Multiple Choice Questions

1. b
2. c
3. a
4. b
5. b
6. b
7. b
8. b

Session 2: Clump Management of Bamboo

A. Multiple Choice Questions

1. b
2. b
3. b

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4. b
5. b
6. b
7. a

Session 3: Maintenance and Protection of Bamboo

A. Multiple Choice Questions

1. b
2. a
3. b
4. b
5. b
6. b
7. a
8. b

Glossary

Auger: It refers to a measuring tool or device, typically used to gauge or assess dimensions, levels, or quantities.

Bamboo: Bamboo is a fast-growing, woody grass belonging to the family Poaceae (Gramineae) and the subfamily Bambusoideae.

Bunds: They are raised soil barriers or embankments, often constructed along the contours of land.

Clone: A clone refers to an organism or cell that is genetically identical to the original organism from which it was derived

Clumping: Clumping in bamboo refers to a growth pattern characteristic of certain bamboo species, where new shoots emerge closely together in a tight cluster around the parent plant. Clumping bamboos, also called sympodial bamboos, grow in a compact, non-invasive manner, spreading outward gradually without sending long, underground runners like running (monopodial) bamboos do.

Culm: In the context of bamboo, a culm refers to the main stem or stalk of the bamboo plant. It is typically hollow and cylindrical, contributing to the plant's lightweight yet strong structure. Culms vary in size, shape, and color depending on the species of bamboo, and they play a crucial role in the plant's growth and reproduction.

Culm Sheath: It is a protective covering that encases the emerging shoot of a bamboo plant.

Internode: A segment of culm, branch, or rhizome between nodes.

Gregarious flowering: In bamboo, it refers to a rare, synchronized flowering event where nearly all individuals of a bamboo species or population flower simultaneously over a large geographical area, regardless of their location. This mass flowering typically occurs after long intervals, ranging from 20 to over 100 years, depending on the bamboo species. After gregarious flowering, most bamboo plants produce seeds and then die off, a phenomenon that can lead to large-scale regeneration from the seeds but also temporary ecological disruptions.

Monocarpic: It refers to plants that flower, set seeds, and then die after completing their life cycle

Monopodial: It describes the growth habit of the rhizomes of running temperate bamboos. The main rhizome continues to grow underground, with some buds producing side shoots (new rhizomes) and others producing aerial shoots (new culms).

Node: The joint between hollow segments of a culm, branch, or rhizome; the point at which a rigid membrane of vascular bundles lends strength to an axis of bamboo by crossing it from wall to wall.

Propagule: It refers to any plant structure that can give rise to a new individual through asexual or sexual reproduction. This term encompasses various forms of reproductive materials.

Rhizome: A food-storing branch of the underground system of growth in bamboos from buds of which culms emerge above ground. Popularly known as rootstock, rhizomes are basically of two forms: sympodial (tropical, clumping, *Pachimorp*h) and monopodial (temperate, running, *Leptomorph).*

Rhizome sheath: It is a protective, modified leaf-like structure that encases the young rhizomes (horizontal underground stems) of bamboo.

Running bamboo: It refers to bamboo species with an aggressive, spreading growth pattern characterized by long, horizontally growing underground stems called rhizomes.

Shoot: A shoot in bamboo refers to the young, newly emerging stem that grows vertically from a rhizome or culm bud.

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Sympodial: It refers to a growth pattern in bamboo where the plant grows in a clumping, compact manner. Also known as clumping bamboo, sympodial bamboo species have short, thick rhizomes that grow closely around the parent plant, producing new shoots near the base rather than spreading outward through long rhizomes, as seen in monopodial or running bamboos.

Vegetative propagation: It is a method of asexual reproduction in plants where new individuals are produced from the parent plant without the formation of seeds. This technique involves using vegetative parts of the plant, such as stems, roots, or leaves, to create new plants that are genetically identical to the parent.

Transplanting: It is the technique of moving a plant from one location to another.

Tissue culture: It is a modern biotechnology technique used to grow and propagate plants in a controlled environment under sterile conditions. It involves taking small pieces of plant tissue, such as cells, shoots, or meristems, and placing them in a nutrient-rich medium that supports growth.

Nursery: It is a designated area or facility where plants, trees, and shrubs are cultivated, grown, and nurtured for sale, transplanting, or conservation purposes.

Topography: It refers to the arrangement and features of the surface of the Earth or a particular area, including its relief (elevation), landforms, and physical characteristics. It encompasses various elements such as mountains, valleys, plains, hills, and bodies of water, and can also include human-made structures like roads and buildings.

Trowel: It is a small hand tool with a pointed, scoop-shaped metal blade and a handle, primarily used for digging, spreading, or shaping soil and other materials.

Veneers: Veneers are thin slices of wood, usually less than 3 mm thick, that are typically glued onto core panels.

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