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SEED CERTIFICATION, ORGANIC FARMING AND HORTICULTURAL PRACTICES

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PREFACE

"If agriculture goes wrong, nothing else will have a chance to go right"

\- M. S. Swaminathan

Biological fertilizers made primarily from animal and plant wastes and nitrogen-fixing cover crops are used in organic farming, a sustainable agricultural approach. Modern organic farming has many ecological advantages and was created in reaction to the harm that synthetic fertilizers and chemical pesticides in conventional agriculture were causing to the environment. Organic farming employs fewer chemicals than conventional agriculture, lessens soil erosion, reduces nitrate leaching into groundwater and surface water, and recycles animal waste back into the farm. These advantages are offset by decreased yields and generally higher food costs for consumers. Indeed, it has been discovered that, on average, the yields of organic crops are roughly 25% lower than those of conventionally grown crops; however, this can vary greatly depending on the type of crop. Future organic agriculture will face problems from climate change and a growing global population, including how to maintain its environmental advantages, boosts yields, and lower prices.

The area of plant agriculture known as horticulture deals with garden crops, primarily fruits, vegetables, and ornamental plants. Its root words are hortus, which means "garden," and colere, which means "to cultivate." All garden management techniques are included under this umbrella word, although in everyday usage, it refers to heavy commercial output. Although all forms of cultivation inherently have tight ties, horticulture is positioned between backyard gardening and field agriculture in terms of scale

Seed is an essential component of agriculture that not only ensures farmers' livelihoods but also provides food security. Through its seed certification, seed quality control, and seed testing departments, the Department of Seed Certification and Organic Certification has been painstakingly working for four decades to ensure that Tamil Nadu farmers receive high-quality seeds. To maintain the genetic purity and identity of a specified type or variety, the Seed Certification Division is responsible for overseeing high-quality seed production at the field level and during processing. Every year, 110000 MT of seeds are certified, and 57000 hectares of seed farms are registered.

This book serves as a bridge between the biological sciences and other disciplines, opening the door for new study in the relevant field. The experiments outlined in the boom chapters are ones that every student of Biology and Chemistry should carry out. They also make a great starting point for a course on qualitative and quantitative analysis. This book will be very helpful to all academics, researchers, and students working in the subjects of chemistry, biology, physics, materials science, and engineering, among other fields.

This book with valuable book chapters from eminent scientists, academicians, and researchers will surely be a part of almost information for the coming new research taken by the researchers in the field of chemical sciences and other disciplines in the future.

Dr. Rakesh Mehta

Dr. Bassa Satyannarayana

Mr. Mukul Machhindra Barawnt

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AGROFORESTRY: A REVIEW

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ABSTRACT

Agroforestry was practiced from the date man learned agricultural practices. It is a common practice of integrating planting trees of varied types in farming systems with crops and or animals on different soil types. Economic and ecological interactions exist between the two components of agroforestry i,e between woody perennial trees and the non-woody component present in the same farmland unit. Agroforestry practices can be sequential or simultaneous depending on the growing of crops with woody perennial trees. Depending on environmental, economic, and social problems in a given area, different designs in agroforestry and practices can be applied. Agroforestry practice intends to increase the farmland productivity and welfare of farmers living largely in rural areas. Growing trees with crops in fields has seen an explosion of research innovations in the early 1990s. With the introduction of these innovations, agroforestry has seen an increase in the success rate. Promising increase in production rate in the fields and increase in incomes of farmers by practicing agroforestry are two important driving forces of success in the field of agroforestry. The growth of industries and the shrinking of agricultural land are the prime factors that forced the stakeholders to introduce new practices in the field of agriculture for its optimum use. Analysis of the role of trees can be made in agroforestry systems at various levels. At the first level knowledge about the land use system is carried out, at the second level is to trace different categories within land use systems, and in the next third level, further discrete groups of components like trees, crops, and animals are studied and in the fourth level, such discrete groups functionality and their connections in time and space are analyzed. For sustainable agroforestry practices, we have to understand farmers designing strategies, long-term land use decisions, development, and marketing. This article will highlight these aspects of agroforestry in detail.

KEYWORDS: Perennial trees, Environment, carrying capacity, Agroecosystems, Land use systems

INTRODUCTION

Nations prosper when there is high productivity from agricultural fields. Gross domestic product (GDP) increases with more contribution from the agriculture and allied sector. For optimum use of agriculture fields, various innovations and practices are being used in the farming culture by the stakeholders. Farmers try their best to get maximum from the fields during various seasons and thus, to become economically strong. Agroforestry is a practice of farmers, in which perennial woody trees (Trees, Shrubs, palms, etc) are grown on the same farmland on which other crops (Non-woody plants) and or animals are present. Tree domestication is more recent than annual crop cultivation. It is the type of symbiotic relationship that is established between crops grown over farmland with the trees simultaneously present with the crops on the same farm. It is believed that Prophet Amos started tree domestication of ficus trees some 2800 years ago. According to Nair 1989, agroforestry has been defined in different ways. International Center for Research in Agroforestry (ICRAF) has defined agroforestry recently as "a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit". Sanchez in 1995 said that this definition has given the right to agroforestry to be studied as a separate branch in agriculture sciences. Agroforestry in general includes the growing of trees on farms and rural landscapes. Agroforestry should not be restricted only to growing woody perennial trees with non-woody crops. Sometimes woody perennial trees like Apple, Plum, and Pear are used as crops. According to Beer in 1987, agroforestry practices also involve simultaneous cultivation of timber and or shade trees with productive tree crops. Libby in 1973 was among the first who gave the domestication of tree concept. During that time mostly timber trees were the main focus. Later on, a conference was held in 1992 in Edinburg, on "Domestication of Tropical trees" in which it was resolved to cultivate trees with the domestication concept. Recently tree domestication is not restricted now; the sphere has embraced new herbaceous crops where the need for shade-tolerant crops is required. The wide variety of trees that are integrated with other crops includes trees used for the land generation, fruit trees that provide nutrition and additional income, fodder trees used to feed livestock, timber producing and fuel wood trees, medicinal trees used for centuries as folklore medicine, trees used to produce gums, resins and there are many other types of trees with multipurpose usage. These trees grown on the agricultural fields play a crucial role in the sustenance of people's livelihood where there is a present fragile ecosystem. Figure 1 depicts a relationship between agroforestry and the solution to poverty among farmers. A mosaic pattern of agroforestry practices can be seen depending on the type of landscape and regional demands. These patches have different species of trees, ecological structures, and usage. It is estimated that around 1.2 billion farmers (Supriya K. Salimath et al 2021) around the world practice agroforestry and in India according to current estimates 25.31 million hectares which accounts for 8.2 percent of the total geographical area of the country is under agroforestry. Around the world, agroforestry was practiced differently during the nineteenth century. In tropical America, farmers were planting a variety of crops with different growth habits. In this practice in less than one-tenth of a hectare, had on average two dozen different species of plants with layered configurations. In Asia, a sophisticated type of shifting cultivation was practiced in the Philippines. On the cleared forest used for cultivation, certain selected trees were deliberately left at the end of the rice growing season. This would have provided a partial canopy of new foliage to crops that need more moisture than excessive sunlight for maturing gain. In Africa crops like beans, maize, yams were grown together with trees scattered. In western Nigeria, an intensive mixed system of herbaceous, shrub, and tree cropping was practiced to conserve human energy along with making full use of limited space obtained from dense forests. In brief integration of perennial trees and shrubs with annual crops produce fuelwood, medicine, fruits, fodder, and other products besides the main crop.

CLASSIFICATION OF AGROFORESTRY PRACTICES

Nair in 1985 has given two stage process of classification depending on components involved in agroforestry and predominant land usage (Fig. 1),

a) Primary classification and

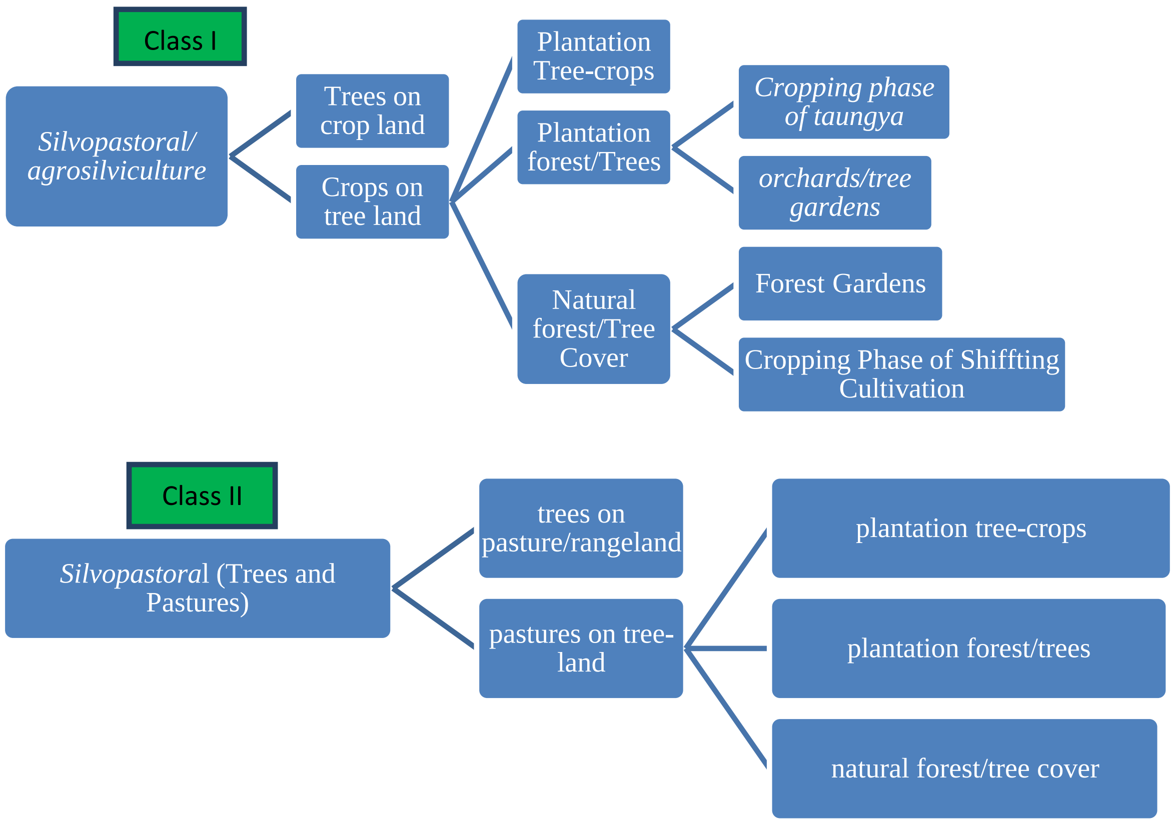
b) Secondary Classification

PRIMARY CLASSIFICATION

On the basis of components involved and land usage, Nair identified five types of agroforestry practices or classes:

- Silvopastoral/agrosilviculture
- Silvopastoral
- Trees and animals (not pasture)
- Forest trees and people
- Trees and perennial agricultural tree crops

Components that Nair identified in agroforestry are types of crops (arable and plantation tree crops), tree and animal combinations, trees and people combinations. The criterion of land use tries to distinguish in the types of tree cover like natural vegetation, human-planted forest, or tree crop plantation. This scheme of classification divides agroforestry into a series of groups which include major types based on ecological and management criteria. This classification is easy and helpful in the identification of practices in various bioclimatic regions. The nomenclature used in classification depends on the importance and placement of components in any agroforestry system e.g agricultural crop in agrisilviculture is a prime component



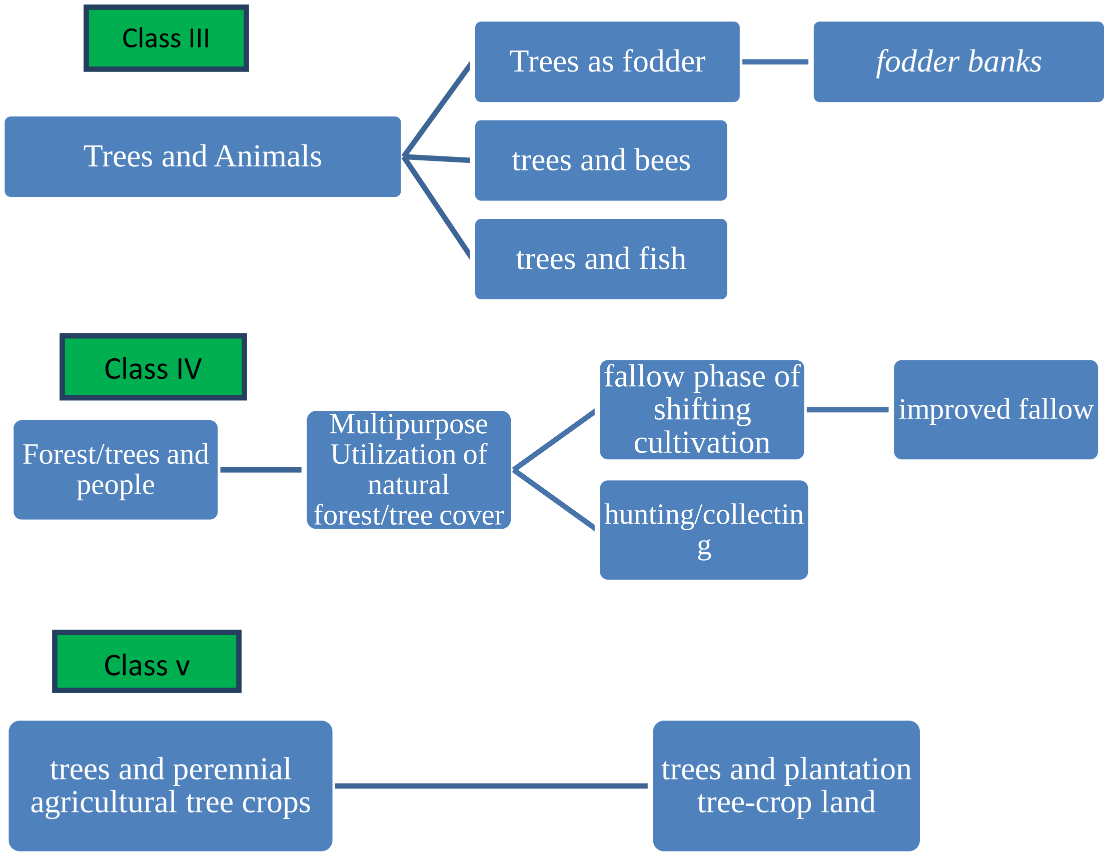


Fig.1: Primary classification of agroforestry practices

SECONDARY CLASSIFICATION

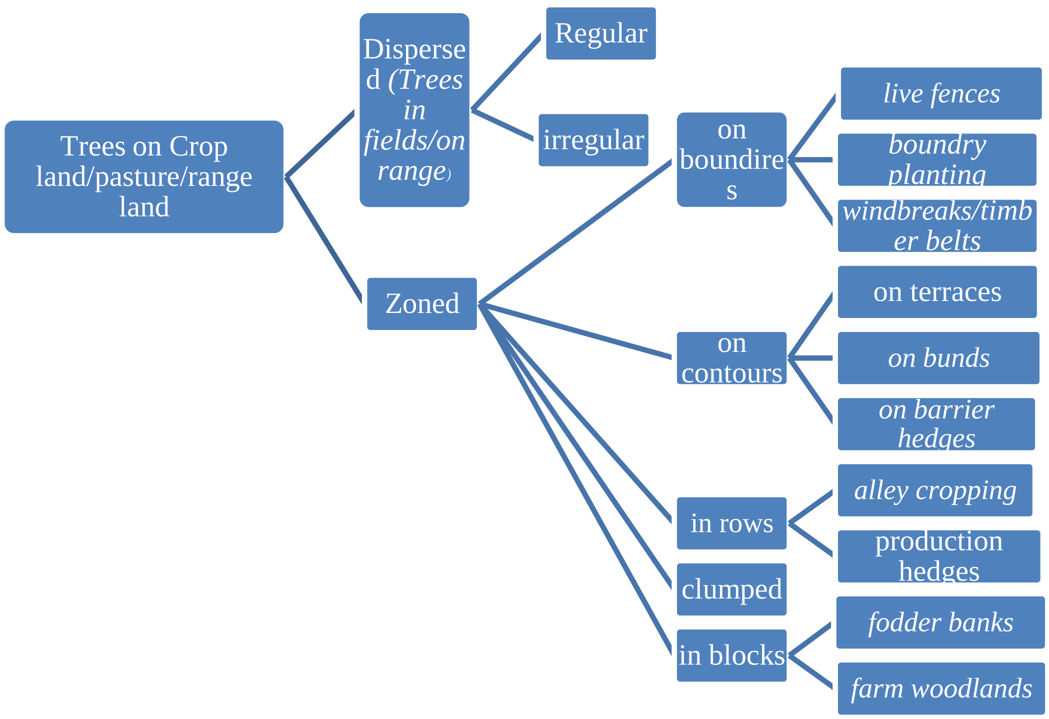


Fig. 2: Secondary classification of agroforestry practices

This classification is based on the arrangement of woody trees that act as permanent components in the agricultural field, and their intimate association with other agricultural components. The trees may be dispersed throughout the field or may be grouped. Zonation of trees ensures that tree top area is minimized with respect to crops. Based on the arrangement, diversity, and density of components, agroforestry practices are secondarily classified as shown in figure 2.

Need for tree domestication: With the increasing land area under cultivation and a decrease of nearly 1% annually in tropical forest cover, this is a market-led and farmer-driven process in agroforestry, in which tree domestication focuses on human desires and stability of agroecosystems. The contribution of tree domestication in agroforestry is to reduce poverty, and enhance food security and nutritional quality in poor community. Tree domestication has been defined as inducing desirable genetic variation in trees as per human needs. Emphasis is given to the identification of local domestication of trees with multitrait desirable qualities. These market-oriented desirable traits are called ideotypes. But this is unlikely that an ideal desirable multitrait tree is readily available. Thus, a large number of tree species are to be screened before final selection. This will provide an incentive to farmers through the commercialization of indigenous trees. Additionally, to achieve the maximum out of Millennium Development Goals through tree domestication there is a need for the improvement of the germplasm of trees and widespread awareness among the stakeholders. In the tropics, tree domestication occurs in forests, fallow lands, farms and secondary forests. Humans throughout the tropics (Pan tropical) screen and select trees that are often termed non-timber forest product (NTFPs) trees. Examples of NTFPs are pine nuts, tree nuts, tree oils, resins, etc. There are certain species of trees included in NTFPs that also produce valuable timber e.g. medicinal species of Prunus afaricana. To remove this ambiguity authors, suggest a new term for these trees referred to as Agroforestry Tree Products (AFTPs).

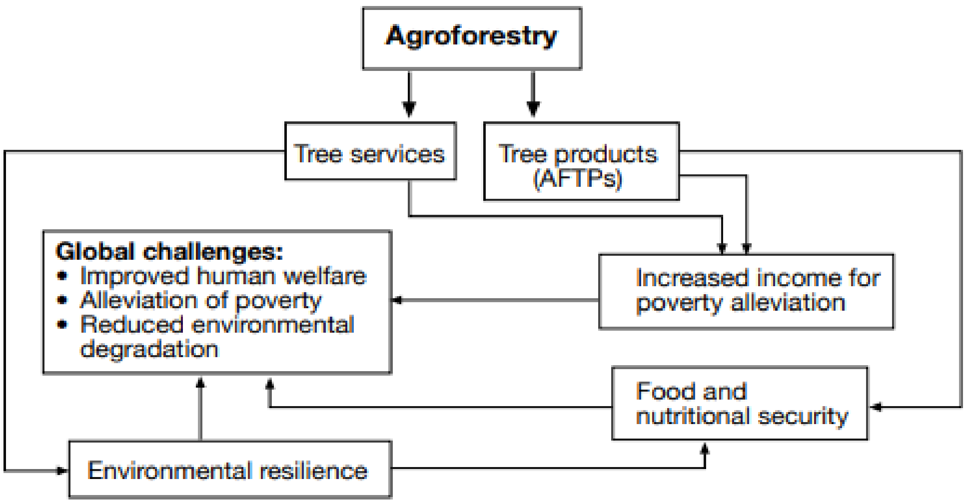


Fig. 3: Showing relationship between agroforestry and mitigation of poverty (Courtesy: Leakey and Tomich 1999 *AFTPs =Agroforestry Tree Products)

PROSPECTS OF AGROFORESTRY

According to a recent study of FAO among 117 developing countries, 54 do have sufficient land resources for their growing population. These countries have been put in a critical category list that covers an area of 2.2 billion hectares of land. Projections are made that shortly, the number of critical nations will increase to 64 and their population may be over 500 million. In these countries carrying capacity of land has already been overstretched. Hope has now been raised to address these serious issues through the use of modern agricultural production technology. Their use will not only increase the carrying capacity per cubic volume of soil, water, and air but will also increase the nutritional quality of food production. It is obvious for ecological and economic sustainability of food production; maintenance of tree cover is most important. Agroforestry practice answers our quandary which allows economic and ecological symbiosis between woody and non-woody components on farmlands. This ensures production output increases its sustainability along with diversifying cultural practices.

Over the past many decades agroforestry has been changed from traditional practice to such natural resource management which is science based and is meant in mitigating poverty among farmers, raise their living standards, and to increase crop production. In this direction targets have been set by Millennium Development Goals (MDGs), which aims at eradication of hunger, and poverty in rural population and to elevate their standards of education and status of woman, strategy is to be set to cover as many families as possible who are going to adapt agroforestry practices. These MDGs aims have been converted to seven goals to achieve the targets;

1. **Eradication of Hunger:** It is to identify the rural areas where people are living in distress condition and have no access to food sources. In these areas agroforestry methods are to be introduced to increase soil fertility in fields where crops are grown. More land is to be identifying for regeneration and adoption of agroforestry practices.
2. **Reduce Poverty in rural areas:** Trees that have more market value are to be identified and grown on farmland and their distribution among beneficiary should be ensured.
3. **Improvement of Health and nutrition:** Areas that can improve health and nutrition in rural poor families, trees that are medicinally important be planted on farms.
4. **Biodiversity conservation:** Incorporation and adoption of policies in agroforestry, innovative institutions can help in conservation of local biodiversity.
5. **Watershed services:** By agroforestry based solutions poor farmers are too rewarded.
6. **Adaptation of Climate Changes:** Carbon marketing is a new trend worldwide in which farmers can be benefitted through tree cultivation awareness programs.
7. By building and bridging capacity of humans and institutional research and development.

CONCLUSION

It is a fact that agroforestry is beneficial in many respects. It has social, economic, and environmental impacts. To release pressure on forest resources, agroforestry offers an alternative. Farmers need not to visit forests for their needs when trees with multitrait characteristics are present on their farmlands. Nutrient cycling becomes more efficient and microclimate is improved by agroforestry. There are more increments for formers in adopting agroforestry practices than traditional ones. The farmers' social and economic condition improves. The need of an hour is to adopt more recent techniques and practices to harvest the maximum benefits of agroforestry practices.

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Chapter
2

ORGANIC FARMING: AN OVERVIEW

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ABSTRACT

Organic Farming use methods to increase crop yields without harming the natural environment. Early in the 20th century, organic farming became popular, mainly in Europe and the US. Simply feeding the soil is the foundation of organic farming. No single strategy can sustainably feed the world. Instead, a combination of organic farming approaches such as use of Organic Fertilizers, Integrated Pest Management tactics, Animal Husbandry, Crop rotation is required. However, these systems face significant obstacles for adoption, necessitating a variety of policy tools to aid in their creation and application.

KEYWORDS: Organic Farming, Organic Fertilizers, Integrated Pest Management, Crop rotation.

INTRODUCTION

In India, organic farming has long been a common practice. It is a farming method that highlights with organic wastes (such as crop, animal, and farm wastes, and aquatic wastes) as well as other biological materials and beneficial microbes (also known as "bio fertilizers") to release nutrients to crops for increased sustainable production in a pollution-free environment.

The living portion of the soil, known as the soil food web, is made up of bacteria, fungus, earthworms, insects, and a variety of other creatures that break down organic materials and feed developing crop plants.

The concept of organic farming is mainly based on the following principles.

1. Nature is the best example for farming because it doesn't require a lot of water or other inputs.
2. A deep comprehension of nature's workings forms the foundation of the whole system.
3. In this approach, the soil is a living thing.
4. The soil's live population of bacteria and other creatures contributes significantly to its fertility throughout time and must therefore be maintained and safeguarded at all costs.
5. The entire soil ecosystem, including the soil's structure and soil cover, is crucial.

DEFINITION OF ORGANIC FARMING

1. The organic farming is defined as a farming system which primarily aims at cultivating the land & raising crops in such a way, so as to keep the soil alive & in good health by use of organic wastes.
2. Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and

this is accomplished by using on farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs''.
(https://www.fao.org/organicag/oa-faq/oa-faq1/en/)

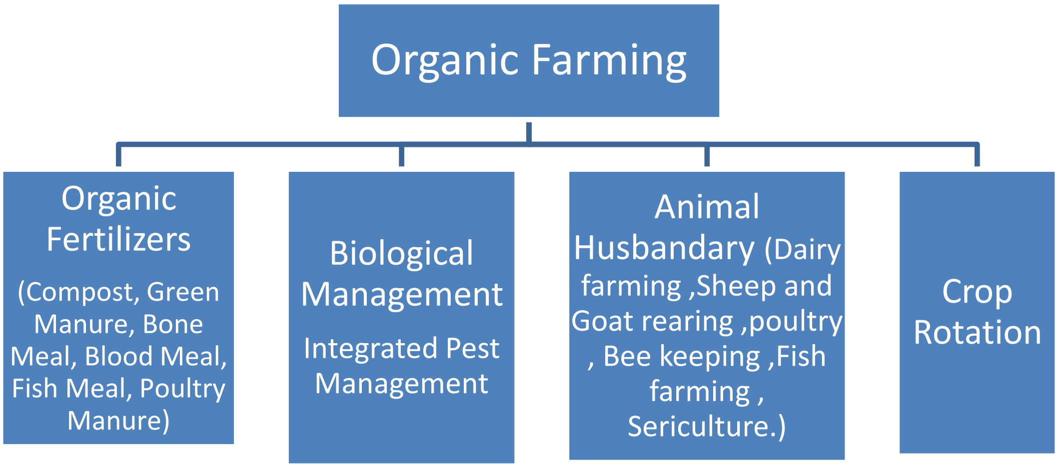

Fig. 1: Organic Farming

Agriculture has a wide scope. For our basic needs of food and clothing we make use of plants and animals beside the cultivation of different crops, cattle, sheep and goat, maintaining poultry farms keeping bees, sericulture, horticulture, pig farming are including in agriculture cultivation of crops is considered to be the main and the most important occupation.

NEED OF ORGANIC FARMING

1. Increase long term soil fertility.
2. Control pests and diseases without harming the environment.
3. Ensure that water stays clean and safe.
4. Make use of the farmer's existing resources to reduce the amount of money needed to buy agricultural equipment's.
5. Produce nutrition food, feed for animals and high quality crops to sell at a good price.

ORGANIC FERTILIZERS

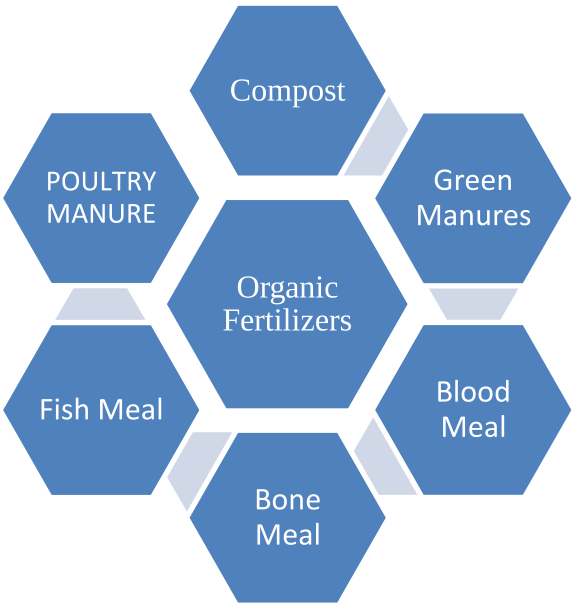

Fig. 2: Organic Fertilizers

- The term "Organic Fertilizers" is defined as "materials used as fertilizers that occur regularly in nature, typically as a byproduct or end product of a naturally occurring process."

COMPOST

Compost is organic matter (plant and animal residue) which has been degraded by the action of bacteria and other organisms, over a period of time. Organic material such as leaves, fruit skins and animal manure can also be used to make compost. Compost is cheap, easy to make. Compost is a very effective material that can be added to the soil, to improve soil and crop quality. Compost improves the structure of soil. This allows more air into the soil improves drainage and reduces erosion. Compost improves soil fertility by adding nutrients and by making it easier for plants to take up the nutrients present in the soil. This produces better yields

GREEN MANURES

A growing crop, such as legume crops, Beans, that is ploughed under the soil to improve fertility. Green manures are usually dug into the soil when the plants are still young, before they flower. They are grown for their green leafy material which is high in nutrients & provides soil cover. Green manure s often known as cover crops. A growing crop, such as legume crops, such as Beans, that is ploughed under the soil to improve fertility. Green manures are usually dug into the soil. The most useful green manure crops are legumes such as clover, beans, peas, Sesbania etc.

ADVANTAGES OF GREEN MANURE

- Increase & recycle plant nutrients & Organic matter.
- Improve soil fertility & soil structure.
- Improve the ability of the soil to hold water.
- Control soil erosion & prevent weed growth
- Stop nutrients being washed out of the soil, when the ground is not used between main crops.

BLOOD MEAL

The dried and powdered blood of animals, used as a nitrogen-rich fertilizer for plants. It is an excellent source of Nitrogen. It is a soluble in water & can be applied as a liquid form. It effectively raises the nitrogen levels in the soil. Blood meal fertilizers can help to adjust soil pH of some plants, such as broccoli, asparagus cucumbers, etc., need more nitrogen, in which case blood meal fertilizer meets the plants' need for nitrogen. It promotes lush green foliage and maintains plants producing fruit and flowers.

BONE MEAL

Bone Meal is a mixture of finely ground animal bones. It is used as an organic fertilizer for plants and as a nutritional supplement for animals. As a slow-release fertilizer, bone meal is primarily used as a source of phosphorus, calcium and protein, which are necessary for strong root development, the avoidance of illness, and promoting plant growth. Bonemeal also contains vital micronutrients like magnesium, zinc, and iron that promote plant health and aid in the development of soil microbial life. It is available in granular and powdered forms.

FISH MEAL

Fish Meal is a (LIQUID) Ground dried fish used as fertilizer. It is good source of micronutrients. It is used to feed container-grown plants every 2 weeks.

POULTRY MANURE

Poultry manure, are used as an organic fertilizer, particularly for soils with low nitrogen levels. It has the most nitrogen, phosphate, and potassium of any animal dung.

ADVANTAGES OF ORGANIC FARMING

- Made up of naturally occurring sources.
- They lower the amount of greenhouse gases that are released into the atmosphere.
- Nutrients are released only when media is warm & moist.
- Provides essential nutrients to plants, they also improve soil structure.
- Organic matter helps to break up heavy clay soil, improve air circulation & drainage, & it increases the capacity for sandy soils to retain moisture
- Make it easier for the roots of plants to reach moisture & to absorb the nutrients in the soil.
- When used over a long period of time during in ground production organic fertilizer may increase the quality of the soil.

LIMITATIONS OF ORGANIC FARMING

- Generally, costs significantly more than synthetic fertilizer.
- Requires regular inspections.
- Motivations for using of vary from user to user. Business may want to go organic in order to sell product, & members of the general public might be interested in organic fertilizer for home use because of environmental concerns. This would increase the cost of the final produced

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Chapter
3

ALLELOPATHY EFFECTS ON COMMERCIAL PLANTS

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ABSTRACT

Allelopathy, the chemical interaction between plants that influences the growth and development of neighboring plants, has significant implications for commercial crop production. While allelopathy can have both positive and negative effects on commercial plants, understanding and managing its impacts are crucial for optimizing crop productivity and sustainability. This abstract provides an overview of the allelopathy effects on commercial plants and highlights key aspects related to its management. The positive effects of allelopathy include weed suppression, pest and disease resistance, and improved nutrient uptake. Allelopathic interactions can contribute to the natural defense mechanisms of commercial plants, reducing the reliance on synthetic pesticides and fertilizers. These interactions can also enhance crop productivity and quality, leading to improved market value. However, allelopathy can also have negative effects on commercial crops. The release of allelochemicals from allelopathic plants can inhibit the growth and development of neighboring commercial plants, resulting in reduced yield and quality. Allelopathic interference can manifest as stunted growth, leaf chlorosis, reduced seed germination, and allelopathic crop-crop or crop-weed interactions.

To manage allelopathy effects on commercial plants effectively, several strategies can be employed. Crop rotation and intercropping can disrupt allelopathic cycles and minimize the buildup of allelochemicals in the soil. Careful selection and breeding of allelopathic crop varieties with reduced negative impacts on neighboring plants can help maintain compatibility and optimize crop performance. Implementing sound soil management practices, such as organic matter incorporation, cover cropping, and nutrient management, can improve soil health and reduce allelopathic effects. Additionally, proper timing and scheduling of planting and harvesting can help minimize allelopathic interference. Regular monitoring and assessment of allelopathic interactions are essential for understanding the extent of the effects and guiding management decisions. Field observations and laboratory analysis of soil samples can provide valuable insights into allelopathic interference and aid in devising appropriate management approaches.

In conclusion, allelopathy effects on commercial plants can significantly influence crop productivity and sustainability. By understanding the mechanisms of allelopathic interactions and implementing appropriate management strategies, farmers can harness the benefits of allelopathy while mitigating its potential drawbacks. Continued research and exploration of specific allelopathic interactions are necessary to develop effective and sustainable agricultural practices.

KEYWORDS: Allelopathy, commercial plants, management strategies, crop rotation, intercropping, allelopathic crop varieties, soil management, timing and scheduling, monitoring, sustainability.

INTRODUCTION

Allelopathy refers to the chemical interactions between plants that influence the growth, development, and survival of neighboring plants. These interactions involve the release of biochemical compounds from one plant species that affect the physiology and metabolism of other plant species. In this chapter, we will explore the allelopathic effects on commercial plants, examining both the positive and negative aspects of these interactions. Understanding allelopathy is crucial for effective crop management and maximizing agricultural productivity.

POSITIVE EFFECTS OF ALLELOPATHY ON COMMERCIAL PLANTS

Allelopathy can have several positive effects on commercial plants, contributing to their growth, productivity, and resilience. Research studies have demonstrated the following benefits:

Weed Suppression: Certain commercial crops possess allelopathic properties that suppress the growth and development of weeds. Allelochemicals released by these crops inhibit weed germination, seedling establishment, and nutrient uptake, reducing competition for resources and minimizing the need for herbicides (Kato-Noguchi and Ino, 2019). For example, allelopathic rice varieties have been shown to effectively suppress the growth of weeds such as barnyard grass and water hyacinth (Olofsdotter *et al.*, 2002).

Disease and Pest Resistance: Allelochemicals released by commercial plants can act as natural defense mechanisms against diseases and pests. These compounds inhibit the growth and activity of pathogens and pests, enhancing the resistance of commercial crops (Rice, 2019). Studies have shown that allelopathic compounds present in crops such as wheat, barley, and rye can suppress the growth of fungal pathogens and reduce the incidence of diseases (Blum, 2011).

Enhanced Nutrient Uptake: Allelopathic interactions can enhance nutrient uptake efficiency in commercial plants, leading to improved growth and productivity. Allelochemicals released by certain plant species stimulate the activity of nutrient-absorbing enzymes and enhance the availability and uptake of essential nutrients (Rizwan *et al.*, 2016). For instance, allelopathic compounds released by sunflowers have been found to increase the uptake of phosphorus in neighboring crops (Bais *et al.*, 2006).

Allelopathic Crop Rotation: Incorporating allelopathic plants into crop rotation systems can provide numerous benefits. These plants release allelochemicals into the soil, which suppress weed growth, control pests and diseases, and improve soil health (Weston, 2019). Crop rotation with allelopathic plants can enhance nutrient cycling, reduce soil-borne pathogens, and improve the overall productivity and sustainability of commercial crop systems (Anaya, 1999).

NEGATIVE EFFECTS OF ALLELOPATHY ON COMMERCIAL PLANTS

While allelopathy can have positive effects on commercial plants, it can also have negative consequences that impact crop growth and yield. Some of the notable negative effects include:

Growth Inhibition: Allelopathic compounds released by certain plant species can inhibit the growth and development of neighboring commercial plants. These compounds can interfere with various physiological and biochemical processes, such as seed germination, root elongation, and photosynthesis, leading to reduced growth and productivity (Inderjit and Duke, 2003). For example, the allelopathic effects of black walnut trees can inhibit the growth of nearby crops such as tomatoes and potatoes (Cipollini *et al.,* 2008).

Reduced Crop Yield: In some cases, allelopathic interactions can result in reduced crop yield. Allelochemicals released by neighboring plants may compete for resources and adversely affect the nutrient uptake and growth of commercial crops (Zhou *et al.,* 2019). This can ultimately lead to lower crop yields and economic losses for farmers.

Interference with Seed Germination: Allelopathic compounds present in the soil can inhibit seed germination and seedling establishment of commercial crops. These compounds may induce dormancy or interfere with the physiological processes required for successful seed germination, resulting in poor crop establishment and reduced stand density (Khanh *et al.,* 2010).

MANAGEMENT STRATEGIES FOR ALLELOPATHY EFFECTS ON COMMERCIAL PLANTS

To mitigate the negative effects of allelopathy and maximize the positive benefits, several management strategies can be employed:

Allelopathy, the chemical interaction between plants that affects the growth and development of neighboring plants, can have both positive and negative effects on commercial crops. To mitigate the negative impacts and maximize the benefits, it is crucial to implement effective management strategies. This chapter explores various approaches and techniques for managing allelopathy effects on commercial plants. By employing these strategies, farmers can optimize crop productivity while minimizing the potential drawbacks of allelopathic interactions.

Crop Rotation and Intercropping: Crop rotation and intercropping are important management strategies for alleviating the negative effects of allelopathy on commercial crops.

Crop Rotation: Incorporating crop rotation can help break allelopathic cycles and reduce the buildup of allelochemicals in the soil. By alternating allelopathic crops with non-allelopathic crops, farmers can disrupt the continuous release of allelochemicals, allowing the soil to recover and reducing the impact on subsequent crops (Abdul-Baki and Teasdale, 1997). This approach minimizes allelopathic interference, maintains soil fertility, and improves overall crop health.

Intercropping: Intercropping involves growing two or more plant species together in close proximity. This practice can help mitigate allelopathic effects by promoting biodiversity and species interactions. Mixing allelopathic crops with non-allelopathic companion plants can reduce the concentration of allelochemicals in the soil, buffer their negative effects, and enhance overall crop productivity (Khanh *et al.,* 2010). Strategic selection of compatible plant combinations is crucial to optimize the benefits of intercropping and minimize allelopathic interference.

Allelopathic Plant Selection: Careful selection of allelopathic crops is vital to manage allelopathy effects on commercial plants.

Plant Breeding and Genetic Selection: Plant breeding and genetic selection techniques can be employed to develop allelopathic crop varieties with reduced negative impacts on neighboring plants. By selecting for reduced allelopathic activity or developing varieties with altered allelochemicals profiles, breeders can minimize the adverse effects on crop growth and yield while still harnessing the positive aspects of allelopathy (Rice, 2019). This approach allows farmers to cultivate allelopathic crops that have improved compatibility with other commercial plants.

Soil Management Practices: Implementing appropriate soil management practices can help alleviate allelopathic effects on commercial crops.

Organic Matter Incorporation: Adding organic matter to the soil can improve soil structure, nutrient availability, and microbial activity, thereby reducing the negative impacts of allelopathy. Organic matter incorporation enhances soil health and fertility, creating a favorable environment for crop growth and minimizing the allelopathic suppression of commercial plants (Weston, 2019).

Cover Cropping: Integrating cover crops into the cropping system can help mitigate allelopathic effects. Cover crops serve as living mulches, reducing the leaching and accumulation of allelochemicals in the soil. They also contribute to soil organic matter, nutrient cycling, and weed suppression, thereby promoting the growth and productivity of commercial crops (Abdul-Baki and Teasdale, 1997).

Nutrient Management: Proper nutrient management plays a crucial role in reducing the negative impacts of allelopathy. Ensuring balanced nutrient levels and optimizing nutrient availability can enhance the tolerance and resilience of commercial crops to allelopathic compounds (Rizwan *et al.*, 2016). Soil testing, targeted fertilizer application and appropriate nutrient ratios are key components of effective nutrient management.

TIMING AND SCHEDULING

Strategic timing and scheduling of planting and harvesting can help minimize allelopathic interference on commercial crops.

Planting Dates: Adjusting the planting dates of susceptible crops can help avoid the peak release of allelochemicals from neighboring plants. By planting at times when allelochemicals concentrations are lower, farmers can reduce the negative impacts on crop growth and development (Olofsdotter *et al.,* 2002). Proper synchronization of planting schedules with allelopathic crop phenology is essential for optimizing crop performance.

ALLELOPATHY MONITORING AND ASSESSMENT

Regular monitoring and assessment of allelopathic interactions are important for effective management.

Field Observations: Conducting field observations and monitoring the growth and performance of commercial crops can provide valuable insights into allelopathic effects. By carefully observing the presence of symptoms, growth patterns, and yield variations, farmers can identify potential allelopathic interference and make informed decisions regarding management strategies.

Laboratory Analysis: Laboratory analysis of soil samples can help determine the presence and concentration of allelochemicals. This analysis assists in understanding the extent of allelopathic effects on commercial crops and aids in devising appropriate management approaches.

CONCLUSION

Allelopathy can have both positive and negative effects on commercial plants. While allelopathic interactions can contribute to weed suppression, disease resistance, and enhanced nutrient uptake, they can also inhibit growth, reduce crop yield, and interfere with seed germination. Understanding the dynamics of allelopathy and implementing appropriate management strategies are crucial for optimizing the positive effects and mitigating the negative impacts. By utilizing crop rotation, intercropping, proper timing, allelopathic plant selection, and sound soil management practices, farmers can harness the benefits of allelopathy while minimizing its potential drawbacks. Further research and exploration of specific allelopathic interactions among commercial plants are necessary to develop effective and sustainable agricultural practices.

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Chapter
4

PESTICIDE EFFECTS ON CROP

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ABSTRACT

Pesticides play a crucial role in modern agriculture by controlling pests and diseases that can damage crops. However, their use comes with potential risks and consequences. This chapter explores the effects of pesticides on crops, including both positive and negative aspects. The positive effects include pest and disease control, increased crop productivity, and enhanced food quality and safety. On the other hand, the negative effects encompass phototoxicity, residue accumulation, non-target effects, development of pesticide resistance, and environmental impacts. To mitigate the negative effects, strategies such as integrated pest management (IPM), proper application techniques, crop rotation and diversity, and monitoring and regulation are essential. By employing these strategies, the negative impacts of pesticides on crops and the environment can be minimized, ensuring sustainable agriculture. Understanding the effects of pesticides on crops is crucial for making informed decisions regarding pesticide use and developing practices that prioritize both crop productivity and environmental stewardship.

KEYWORDS: Food Quality, Crop Rotation, Sustainable Agriculture.

INTRODUCTION

Pesticides play a vital role in modern agriculture by controlling pests and diseases that can damage crops. However, their use comes with potential risks and consequences. In this chapter, we will explore the effects of pesticides on crops, including both positive and negative aspects. Understanding these effects is crucial for making informed decisions regarding pesticide use and developing sustainable agricultural practices.

BENEFITS OF PESTICIDES ON CROP PRODUCTION

Pesticides have several positive effects on crop production, contributing to increased yields, improved quality, and enhanced food safety. Research studies have demonstrated the following benefits:

Pest and Disease Control: Pesticides effectively control pests and diseases, preventing yield losses and protecting crop quality. They target insects, weeds, fungi, bacteria, and other organisms that can harm crops, thereby ensuring a higher yield and improved market value (Mogha *et al.,* 2019). The use of pesticides has been particularly effective in controlling devastating pests such as the diamondback moth in cabbage crops (Zalucki *et al.,* 2012).

Increased Crop Productivity: By minimizing damage caused by pests and diseases, pesticides contribute to increased crop productivity. Healthy plants are better able to utilize resources such as water and nutrients, leading to improved growth and higher yields (Oerke, 2006). For instance, the use of insecticides has been shown to increase grain yield in maize by controlling stem borers and reducing yield losses (Gachango *et al.,* 2019).

Enhanced Food Quality and Safety: Pesticides help maintain the quality and safety of harvested crops by reducing the presence of contaminants. They protect crops from pathogens and minimize the risk of mycotoxin contamination, ensuring that consumers have access to safe and healthy food (Reddy *et al.,* 2020). Studies have found that proper pesticide application significantly reduces the incidence of mycotoxins in crops such as peanuts and corn (Scudamore and Livesey, 2000).

NEGATIVE EFFECTS OF PESTICIDES ON CROPS

While pesticides offer benefits to crop production, they also pose potential risks and negative effects. It is essential to be aware of these effects to minimize their impact. Research studies have highlighted the following concerns:

Phototoxicity: Pesticides, especially when misused or applied in excessive amounts, can have phytotoxic effects on crops. They may cause leaf burn, stunting, discoloration, and even death of plants (Bhowmik *et al.,* 2019). Careful application and adherence to recommended dosage are crucial to prevent such damage. Studies have reported phytotoxic effects of herbicides on crops like soybeans and cotton (Vidal *et al.,* 2017).

Residue Accumulation: Pesticide residues can accumulate in crops, leading to potential health risks for both humans and animals. The persistence of certain pesticides can result in long-term contamination of soil and water, impacting subsequent crops and ecosystems (Aktar *et al.,* 2009). Studies have found pesticide residues in various crops, such as fruits, vegetables, and grains, emphasizing the importance of proper residue management (Bempah *et al.,* 2019).

Non-Target Effects: Pesticides can harm non-target organisms such as beneficial insects, birds, and pollinators, disrupting ecological balances. This can indirectly affect crop production by reducing natural pest control services and impairing pollination, leading to lower yields and imbalanced ecosystems (Goulson, 2013). For example, neonicotinoid insecticides have been linked to declines in bee populations, which can have detrimental effects on crop pollination (Woodcock *et al.,* 2016).

Development of Pesticide Resistance: Continuous and indiscriminate use of pesticides can contribute to the development of resistance in pest populations. Over time, pests may evolve mechanisms to overcome the effects of pesticides, rendering them less effective in crop protection. Integrated Pest Management (IPM) practices can help mitigate resistance issues by integrating multiple control strategies and reducing reliance on pesticides (Georghiou, 1990).

Environmental Impact: Pesticides can have unintended environmental consequences, such as water and air pollution, contamination of natural habitats, and negative impacts on biodiversity. These effects can disrupt ecosystems and pose long-term risks to agricultural sustainability (Pimentel, 2005). Research has shown the detrimental effects of pesticides on aquatic organisms, soil microorganisms, and bird populations (Köhler and Triebskorn, 2013).

MITIGATING THE NEGATIVE EFFECTS

Efforts to minimize the negative effects of pesticides on crops and the environment are crucial for sustainable agriculture. Various strategies can be employed to mitigate these effects:

Integrated Pest Management (IPM): Implementing IPM practices can reduce pesticide use by integrating various pest management strategies. This approach combines cultural, biological, and chemical control methods, prioritizing non-chemical options while minimizing the risks associated with pesticides (Stern *et al.*, 1959). IPM has been successfully implemented in various crops, such as cotton and rice, leading to reduced pesticide use and improved pest control (Gontijo *et al.*, 2012; Heong *et al.*, 2015).

Proper Application Techniques: Appropriate pesticide application techniques, including precise timing, dosage, and application methods, can minimize phytotoxicity and off-target effects. Training farmers on proper handling and application practices is crucial for maximizing efficacy while minimizing negative impacts (Elliott *et al.*, 1996). Research has shown that adopting proper application techniques can significantly reduce pesticide drift and minimize environmental contamination (Matthews *et al.*, 2003).

Crop Rotation and Diversity: Crop rotation and diversification can help break pest cycles, reduce pest pressure, and lower the dependence on pesticides. By varying the crops planted in a specific area, pests that target specific crops can be disrupted, improving overall crop health and reducing the need for chemical interventions (Bender *et al.*, 2016). Studies have shown the benefits of crop rotation in managing pests such as nematodes and weeds (Hooks *et al.*, 2010; Ghimire *et al.*, 2018).

Monitoring and Regulation: Regular monitoring of pest populations, disease incidence, and crop health enables timely and targeted pesticide use. Effective regulations and enforcement of pesticide use, including proper labeling, restricted chemicals, and buffer zones, can minimize the risks associated with pesticide application (Sankula and Oerke, 2021). Proper monitoring and regulation ensure that pesticides are used judiciously and responsibly.

CONCLUSION

Pesticides have both positive and negative effects on crops. While they contribute to increased crop productivity and protect food quality and safety, their misuse or overuse can have detrimental impacts on crop health, the environment, and human health. Employing sustainable and integrated pest management practices, along with proper application techniques and monitoring, is essential for minimizing the negative effects of pesticides while ensuring effective crop protection. By prioritizing the long-term sustainability of agriculture, we can strike a balance between crop productivity and environmental stewardship.

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Chapter
5

PHARMACOLOGICAL POTENTIAL OF PLANTS

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ABSTRACT

The pharmacological potential of plants has long been recognized and utilized in various traditional healing systems around the world. Plants possess a vast array of bioactive compounds that can be harnessed for their therapeutic properties. Over the years, scientific research and advancements in technology have further uncovered the complex chemical compositions of plants and their pharmacological mechanisms of action. This knowledge has led to the development of plant-derived drugs that are used to treat a wide range of diseases. Traditional medicinal systems, with their holistic approach to healthcare, have provided valuable insights into the healing properties of plants. Integrating traditional knowledge with modern pharmacology enables us to combine the wisdom of traditional medicine with scientific rigor. However, the effective utilization of plant pharmacology requires robust quality control and standardization processes. Accurate identification of plant species, standardization of preparation methods, and quantification of bioactive compounds are essential for ensuring consistent efficacy and safety of plant-based medicines. Addressing challenges such as adulteration, contamination, and the conservation of plant resources is crucial to safeguard the quality and sustainability of these medicines. Regulatory frameworks and harmonization of standards play a vital role in ensuring the safety, efficacy, and quality of plant-based medicines. The future of plant pharmacology holds promise, with ongoing research exploring new plant sources, uncovering synergistic effects of multiple compounds, and utilizing innovative technologies for quality control and standardization. By embracing an interdisciplinary approach and leveraging the pharmacological potential of plants, we can unlock novel therapies and improve healthcare outcomes.

KEYWORDS: diseases, pharmacology, medicines, standardization.

INTRODUCTION

Plants have been used for centuries as a source of medicine, providing valuable compounds with therapeutic properties. The diverse array of plant species offers a vast pharmacological potential for the development of novel drugs and treatments. This chapter explores the pharmacological potential of plants, highlighting their medicinal properties, bioactive compounds, and the importance of plant-based research in modern pharmacology.

TRADITIONAL MEDICINAL USES

Plants have long been used in traditional medicine systems worldwide. Indigenous cultures and traditional healers have relied on plant-based remedies for the treatment of various ailments. These traditional uses provide a valuable starting point for modern pharmacological investigations, guiding the discovery of potential therapeutic compounds (Gurib-Fakim, 2006).

BIOACTIVE COMPOUNDS

Plants contain a wide range of bioactive compounds, including alkaloids, flavonoids, terpenoids, phenolic compounds, and many others. These compounds possess diverse pharmacological activities and have been associated with numerous health benefits. For example, alkaloids such as morphine from opium poppy (*Papaver somniferum*) have potent analgesic properties, while flavonoids found in plants like green tea (*Camellia sinensis*) exhibit antioxidant and anti-inflammatory effects (Sarker *et al.,* 2004).

ANTI-INFECTIVE AGENTS

Plants have been a valuable source of anti-infective agents, including antibacterial, antifungal, and antiviral compounds. Traditional medicinal plants such as garlic (*Allium sativum*), neem (Azadirachta indica), and tea tree (Melaleuca alternifolia) have been extensively studied for their antimicrobial properties (Rios and Recio, 2005). These natural compounds offer potential alternatives or adjuncts to conventional antimicrobial therapies, particularly in the context of antibiotic resistance.

ANTI-CANCER POTENTIAL

Plant-derived compounds have shown significant potential as anti-cancer agents. Examples include taxanes from the Pacific yew tree (Taxus brevifolia) and vinca alkaloids from the Madagascar periwinkle (*Catharanthus roseus*), which are widely used in cancer chemotherapy (Cragg and Newman, 2013). The discovery and development of plant-based anticancer drugs continue to be an active area of research, with the aim of identifying more effective and less toxic treatments.

NEUROPROTECTIVE AGENTS

Plants contain compounds that exhibit neuroprotective properties, offering potential therapeutic interventions for neurodegenerative diseases. Curcumin, derived from the turmeric plant (*Curcuma longa*), has demonstrated neuroprotective effects in various experimental models of neurodegeneration (Aggarwal *et al.,* 2007). Other plants, such as Ginkgo biloba and Bacopa monnieri, have been traditionally used for their cognitive-enhancing properties and are being studied for their potential in managing neurodegenerative conditions.

MODERN PHARMACOLOGICAL POTENTIAL

Scientific Research and Drug Development: Modern pharmacology employs rigorous scientific methodologies to identify, isolate, and evaluate bioactive compounds from plants. Advances in analytical techniques, such as high-throughput screening and molecular modeling, enable the identification of specific compounds with pharmacological activities (Newman and Cragg, 2020). This approach has led to the development of many modern drugs derived from plant sources, such as aspirin from willow bark (Salix spp.) and artemisinin from sweet wormwood (*Artemisia annua*).

Pharmacological Mechanisms and Targeted Therapies: Modern pharmacology focuses on understanding the pharmacological mechanisms of action of plant-derived compounds. This knowledge allows for the targeted development of therapies that address specific molecular pathways and disease targets. Examples include the use of plant-derived alkaloids in cancer chemotherapy and the development of plant-based drugs for cardiovascular and neurological disorders (Berman *et al.,* 2020).

Quality Control and Standardization: One of the challenges in harnessing the pharmacological potential of plants is ensuring quality control and standardization. Traditional remedies often involve the use of whole plants or plant extracts, which can vary in composition due to factors such as plant species, geographical origin, and harvesting practices. Standardization of plant-based medicines requires the identification and quantification of bioactive compounds and the establishment of quality control measures to ensure consistent efficacy and safety (Gurib-Fakim, 2006).

The utilization of plants for their pharmacological potential, whether in traditional or modern medicine, necessitates robust quality control and standardization processes. Ensuring the consistency, efficacy, and safety of plant-based medicines is crucial for their effective use and integration into healthcare systems. This chapter explores the importance of quality control and standardization in harnessing the pharmacological potential of plants, both in traditional and modern contexts.

Quality Control of Traditional Plant-Based Medicines:

Plant Identification and Authentication: Accurate plant identification is the first step in quality control. Traditional plant-based medicines often involve the use of multiple plant species or plant parts. Therefore, reliable botanical identification is essential to ensure the correct plant materials are used. Various methods, such as macroscopic and microscopic examination, DNA barcoding, and chemical profiling, can aid in plant authentication (Kool *et al.,* 2015).

Standardization of Preparation: Traditional remedies often involve complex preparation methods, such as decoctions, infusions, or fermentations. Standardization ensures consistency in the preparation process, including the use of specific plant parts, extraction techniques, solvent systems, and dosage forms. This helps to maintain batch-to-batch consistency and optimize therapeutic efficacy (Kamatou *et al.,* 2013).

Quantification of Bioactive Compounds: Many traditional plant-based medicines contain bioactive compounds responsible for their pharmacological activities. Quantifying these compounds provides an indication of the medicine's potency and allows for batch-to-batch consistency. Analytical techniques such as high-performance liquid chromatography (HPLC) or gas chromatography-mass spectrometry (GC-MS) can be employed for accurate quantification (Kumar *et al.,* 2018).

Standardization of Modern Plant-Based Medicines:

Isolation and Characterization of Active Compounds: Modern pharmacological research focuses on isolating and characterizing active compounds from plants. Standardization involves the identification and quantification of these compounds, ensuring consistent levels of bioactive constituents in plant-based medicines. This information aids in establishing quality control parameters and allows for reproducible manufacturing processes (Chen *et al.,* 2016).

Marker Compounds and Fingerprints: Marker compounds or chemical fingerprints serve as reference points for quality control. These compounds, often characteristic of a specific plant species or chemical class, are used to verify the authenticity and quality of plant materials. Techniques such as chromatographic fingerprinting, spectroscopy, and mass spectrometry help in the creation of chemical profiles for identification and quality assessment (Chen *et al.,* 2016).

Good Manufacturing Practices (GMP): Modern plant-based medicines adhere to Good Manufacturing Practices to ensure consistent quality and safety. GMP guidelines cover various aspects of manufacturing, including facility design, raw material sourcing, process validation, quality assurance, and documentation. Compliance with GMP standards guarantees standardized production, minimizing variations in product quality (World Health Organization, 2003).

CHALLENGES AND EMERGING APPROACHES

Complex Chemical Profiles: Plant-based medicines often have complex chemical profiles, containing numerous compounds that may contribute to their therapeutic effects. Standardizing such complex mixtures poses challenges due to the variability in composition caused by factors like plant genetics, geographical origin, and environmental conditions. Innovative approaches, such as metabolomics and chemometrics, are being employed to overcome these challenges and enable more comprehensive quality control (Xu *et al.,* 2019).

Adulteration and Contamination: The adulteration and contamination of plant-based medicines are significant concerns in quality control. Adulteration involves the intentional substitution or addition of inferior or unrelated plant materials, while contamination refers to the presence of foreign substances such as heavy metals, pesticides, or microbial contaminants. Strict quality control measures, including extensive testing and adherence to regulatory standards, are necessary to prevent these issues (Heinrich *et al.,* 2019).

Regulatory Frameworks and Harmonization: The establishment of regulatory frameworks for quality control and standardization is essential. Regulatory authorities play a crucial role in ensuring the safety, efficacy, and quality of plant-based medicines. Harmonization of standards at the national and international levels facilitates trade, ensures consistency across different markets, and promotes global best practices in quality control (World Health Organization, 2003).

Intellectual Property and Conservation: The commercialization of plant-based medicines raises important ethical considerations. Traditional knowledge holders and indigenous communities should be recognized and appropriately compensated for their contributions to the discovery and development of plant-based therapies. Additionally, conservation efforts are crucial to preserve plant biodiversity and ensure the sustainable utilization of medicinal plant resources (Cunningham, 2001).

FUTURE PERSPECTIVES AND CHALLENGES

Exploring the pharmacological potential of plants presents both opportunities and challenges. The identification and isolation of bioactive compounds from complex plant matrices require sophisticated extraction and purification techniques. Additionally, the standardization of plant-based products and the elucidation of their mechanisms of action are crucial for their effective utilization in modern pharmacology.

CONCLUSION

Plants possess a rich pharmacological potential, offering a vast array of bioactive compounds with diverse therapeutic properties. Traditional medicinal uses, combined with modern scientific approaches, contribute to the discovery and development of plant-based drugs. The exploration of plant pharmacology provides opportunities for the development of novel therapeutics and the advancement of modern medicine. The pharmacological potential of plants is a vast and valuable resource that has been recognized and utilized for centuries. Plants have provided us with numerous bioactive compounds that serve as the foundation for modern medicine. From traditional healing practices to modern drug development, plants have played a crucial role in improving human health and well-being. Through scientific research and advancements in technology, we have been able to unravel the complex chemical compositions of plants and understand their pharmacological mechanisms of action. This knowledge has led to the identification and isolation of specific compounds with therapeutic properties. Many plant-derived drugs have been successfully developed and used in the treatment of various diseases, ranging from cancer and cardiovascular disorders to neurological conditions. Traditional medicinal systems have accumulated a wealth of knowledge on the therapeutic properties of plants through empirical observations and experience. These traditional practices emphasize a holistic approach to healthcare and have provided valuable insights into the healing properties of plants. Integrating traditional knowledge with modern pharmacology allows us to combine the best of both worlds, leveraging the wisdom of traditional medicine and the scientific rigor of modern research.

However, harnessing the pharmacological potential of plants is not without challenges. Quality control and standardization are critical aspects in ensuring the consistency, efficacy, and safety of plant-based medicines. Accurate identification of plant species, standardization of preparation methods, and quantification of bioactive compounds are essential for maintaining batch-to-batch consistency and optimizing therapeutic efficacy. Furthermore, issues such as adulteration, contamination, and the conservation of plant resources need to be addressed to safeguard the quality and sustainability of plant-based medicines. Regulatory frameworks and harmonization of standards play a vital role in ensuring the safety, efficacy, and quality of these medicines. The future of plant pharmacology is promising, with ongoing research exploring new plant sources, unraveling the synergistic effects of multiple compounds, and utilizing innovative technologies for quality control and standardization. As we continue to deepen our understanding of the pharmacological potential of plants, we have the opportunity to unlock novel therapies and improve healthcare outcomes.

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Chapter
6

BIOLOGICAL ACTIVITY OF MEDICINAL PLANTS

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ABSTRACT

The study of medicinal plants and their biological activities continues to be the primary objective in the field of pharmacognosy. The purpose of this chapter is to provide a comprehensive overview of medicinal plants' biological activities and their importance in drug discovery and development. Through an extensive review of the current literature, this chapter explores various aspects related to the biological activity of medicinal plants, including their phytochemical composition, mechanisms of action, therapeutic applications, and potential challenges. It focuses on the phytochemical composition of medicinal plants. These plants contain diverse secondary metabolites such as alkaloids, flavonoids, terpenoids, and phenolic compounds, which are responsible for their therapeutic properties. We discuss the extraction and isolation techniques employed to obtain these bioactive compounds and the analytical methods used for their identification and quantification. Furthermore, we delve into the importance of standardization and quality control to ensure the potency and safety of medicinal plant-derived products. The subsequent section explores the mechanisms of action underlying the biological activities of medicinal plants. Various studies have elucidated the molecular pathways and targets through which these plant-derived compounds exert their therapeutic effects. With further scientific investigation and responsible utilization, medicinal plants hold great promise for the development of novel drugs to improve human health and well-being.

KEYWORDS: Medicinal plants, Biological activity, Secondary metabolites, Molecular pathways, enzymatic activity, Therapeutic application.

INTRODUCTION

Plants are a good source of remedies and play an important part in the survival of ethnic and tribal societies. Medicinal plants are used to treat many human and animal diseases all over the world. The therapeutic use of indigenous plant products for ethnomedicinal and nutritional purposes has piqued the interest of scientists, prompting them to search for bioactive chemicals. Carbohydrates, fats and proteins are all found in medicinal plants. These components are essential for the human body's needs and are involved in a variety of physiological, metabolic, and morphological functions.

Plant-derived natural products are employed in pharmaceuticals, nutritional supplements, and various healthcare items. Plants and their phytochemical contents, such as antioxidants, hypolipidemic and hypoglycemic ingredients, play an important role in the discovery of new beneficial pharmaceutical components. Many medicines are derived directly or indirectly from plant resources, and plants are frequently a valuable supply of medicines (Nasim *et al.*, 2022).

Plants are necessary for human everyday needs such as food, housing, fibre, and therapeutic uses. For health treatment, people in rural areas have favoured natural medications. There has been an increase in interest in natural therapies derived from plants and their use in rural areas where conventional medicines are commonly available. Medicinal plants include a wide range of physiologically active components, such as minerals and phytochemicals, which have a wide range of physiological effects on humans (Rabizadeh *et al.,* 2022). Angiosperm plants' medicinal and antimicrobial properties are used to treat constipation, dysentery, measles, malaria, onchocerciasis, yellow fever, stomach pain, and other illnesses, although the plant's slender roots and stem branches are used as dental munching sticks.

There has been a surge in interest in botanical sources of natural medications, cosmetics, nutritive supplements, herbal tea, and other health-promoting products in recent years. Medicinal plants have been found all over the world to possess crucial bioactive chemicals that can aid in the prevention of many ailments such as cancer, diabetes, and heart disease (Prasathkumar *et al.,* 2021). Different plant species manufacture secondary metabolites in different ways. These secondary metabolites do not appear to be required for plant growth. Secondary metabolites, on the other hand, have been shown by research to have significant functions in plants, such as protection against ultraviolet radiation exposure, resistance to illnesses caused by viruses, fungus, bacteria, and phytopathogens, and keeping herbivores at bay (Guerriero *et al.,* 2018). These secondary metabolites, which belong to three major families known as polyphenols, terpenes, and alkaloids, are the most interesting in therapeutics. Deficits in micronutrients and minerals may have long-term detrimental effects on human health and result in diseases caused by micronutrient deficiencies (Kiani *et al.,* 2022). All traditional medicines were made from plants, whether they were simple mixtures of crude extracts or samples of various plant sections (Altemimi *et al.,* 2017; Stéphane *et al.,* 2021). The main benefit of employing medications made from plants is that they are typically safer than synthetic alternatives, have powerful therapeutic effects, and are less expensive.

Therefore, the purpose of this chapter is to give a general overview of the mechanism, therapeutic applications, and processes based on the principle of plant secondary metabolites as well as their benefits and drawbacks. This chapter will also highlight typical issues and solutions. Only a few categories and compounds are shown because there are millions of natural products generated from plants that are known.

SECONDARY METABOLITES

Alkaloids, flavonoids, terpenoids, phenolic compounds.

Secondary metabolites are bioactive compounds produced by plants, not involved in primary metabolic processes. They play important roles in plant defence and interactions with the environment. Among them, alkaloids, flavonoids, terpenoids, and phenolic compounds in medicinal plants possess pharmacological properties and therapeutic potential. (Wink, 2010)

ALKALOIDS

Alkaloids are a group of naturally occurring nitrogen-containing compounds that are widely distributed in the plant kingdom. They exhibit a diverse range of biological activities and have been used extensively in traditional medicine. Examples of alkaloids include morphine, caffeine, quinine, and nicotine. These compounds often possess analgesic, antimalarial, anticancer, and antispasmodic properties. For instance, morphine, derived from the opium poppy (*Papaver somniferum*), is a potent analgesic used for pain relief (Khan *et al.,* 2007). The alkaloid vincristine, obtained from the Madagascar periwinkle (*Catharanthus roseus*), is an effective anticancer drug (Taher *et al.,* 2019).

FLAVONOIDS

Flavonoids are a class of secondary metabolites characterized by their diverse chemical structures and wide distribution in plants. They are responsible for the vibrant colours of flowers and fruits and are known for their antioxidant, anti-inflammatory, and anticancer activities. Flavonoids include compounds such as quercetin, kaempferol, and apigenin. Quercetin, found in various fruits and vegetables, has been studied for its potential to reduce the risk of cardiovascular diseases, inflammation-related disorders, and certain types of cancers (Harborne & Williams, 2000).

TERPENOIDS

Terpenoids, also known as isoprenoids, are a large and structurally diverse group of secondary metabolites found in plants. They are derived from the five-carbon building block, isopentenyl pyrophosphate (IPP), and play essential roles in plant defence, as well as in attracting pollinators and seed dispersers. Terpenoids have demonstrated a variety of pharmacological activity, including anti-cancer, anti-fungal, and anti-microbial effects. Examples of terpenoids include menthol, found in peppermint (*Mentha piperita*), and artemisinin, derived from the plant (*Artemisia annua*) used in malaria treatment (Tholl, 2006).

PHENOLIC COMPOUNDS

Phenolic compounds are a diverse group of secondary metabolites characterized by the presence of phenol rings. They are widely distributed in plants and contribute to their colour, flavour, and aroma. Phenolic compounds have gained significant attention due to their potent antioxidant, anti-inflammatory, and anti-cancer properties. Examples of phenolic compounds include resveratrol, found in grapes and wine, and curcumin, derived from the spice turmeric (*Curcuma longa*) (Santhakumar *et al.,* 2018). These compounds have shown promising effects in the prevention and treatment of various serious diseases, like cardiovascular disorders, neurodegenerative diseases, and certain cancers.

IMPORTANCE OF PHYTOCHEMICALS IN THERAPEUTIC PROPERTIES

Phytochemicals are bioactive compounds found in medicinal plants that contribute to their therapeutic properties. These compounds have gained attention in natural medicine and drug discovery due to their diverse pharmacological activities and potential health benefits. They interact with biological targets and modulate physiological processes, making them valuable for healthcare applications.

Antioxidant Activity: Many phytochemicals exhibit strong antioxidant properties, enabling them to scavenge free radicals and reduce oxidative stress in the body. Oxidative stress has been associated with a variety of chronic diseases, including cardiovascular disease, neurological disease, and cancer. Phytochemicals such as flavonoids, phenolic compounds, and carotenoids act as potent anti-oxidants, preventing cells damage caused by free radicals. Research studies have demonstrated the role of phytochemical antioxidants in preventing oxidative damage and reducing the risk of chronic diseases (Bhatt *et al.*, 2013; Surh, 2003).

Anti-inflammatory Effects: Inflammation is a natural defence mechanism of the body, but chronic inflammation can contribute to the development of several diseases, like arthritis, asthma, and inflammatory bowel disease. Phytochemicals like curcumin, resveratrol, and quercetin possess anti-inflammatory properties, inhibiting the production of pro-inflammatory molecules and modulating signalling pathways involved in inflammation. These compounds have shown potential in managing inflammatory conditions and reducing the risk of associated diseases (Gupta *et al.*, 2012; Wang *et al.*, 2013).

Antimicrobial and Antiviral Activities: Phytochemicals have long been used in traditional medicine for their antimicrobial and antiviral properties. Several plant compounds, including alkaloids, terpenoids, and tannins, possess broad-spectrum antimicrobial activity, making them valuable in the treatment of infectious diseases (Stan *et al.*, 2021). For example, berberine, an alkaloid found in various medicinal plants, has exhibited antimicrobial effects against bacteria, fungi, and parasites (Kittakoop *et al.*, 2014). Additionally, certain phytochemicals have shown antiviral activity against viral pathogens, offering potential therapeutic options in viral infections((Lin *et al.*, 2014)).

Anticancer Potential: Phytochemicals have gained considerable attention in cancer research due to their potential anticancer properties. These compounds can interfere with the initiation, promotion, and progression of the various stages of cancer development. Examples of phytochemicals like Curcumin, resveratrol, and epigallocatechin gallate (EGCG) all have anticancer properties. They exert their effects through various mechanisms, including modulation of cell cycle progression, suppression of metastasis, inhibition of angiogenesis, and induction of apoptosis. (Gupta *et al.*, 2010; Zhang *et al.*, 2016).

Phytochemicals hold promise as potential adjuvants in cancer therapy and as chemopreventive agents.

MECHANISMS OF ACTION OF MEDICINAL PLANTS

Mechanisms of action of medicinal plants involve a diverse array of interactions between plant-derived compounds and various molecular targets in the human body. Understanding these mechanisms is crucial for harnessing the therapeutic potential of medicinal plants. Here, we will explore the mechanisms of action, supported by research and professional-level standards, and provide references for further exploration.

Molecular Pathways and Targets of Plant-Derived Compounds: Plant-derived compounds interact with specific molecular targets in the body, such as enzymes, receptors, ion channels, and signalling molecules. For example, curcumin, a compound found in turmeric (*Curcuma longa*), modulates multiple signalling pathways, including NF-κB, STAT3, and PI3K/Akt, involved in inflammation and cancer (Gupta *et al.*, 2012). Resveratrol, abundant in grapes and wine, can activate sirtuin enzymes, influencing cellular metabolism and ageing (Baur & Sinclair, 2006). These examples highlight the potential of plant-derived compounds to target specific pathways and exert therapeutic effects.

Modulation of Enzymatic Activity: Many medicinal plants contain compounds that can modulate enzymatic activity. For instance, berberine, found in various plants such as goldenseal (*Hydrastis canadensis*) and barberry (*Berberis vulgaris*), has been shown to inhibit the activity of enzymes involved in the metabolism of glucose, such as protein tyrosine phosphatase 1B (PTP1B) and AMP-activated protein kinase (AMPK), adding to its anti-diabetic effects (Yin *et al.,* 2008). By interacting with enzymes, plant-derived compounds can regulate various physiological processes.

Interaction with Cell Membrane Receptors: Plant-derived compounds can interact with cell membrane receptors, influencing cellular signalling and response. For example, cannabinoids found in cannabis (*Cannabis sativa*) interact with cannabinoid receptors (CB1 and CB2) in the endocannabinoid system, regulating pain perception, immune function, and neuroprotection (Pacher *et al.,* 2006). Flavonoids present in medicinal plants, such as quercetin and apigenin, can interact with G-protein coupled receptors (GPCRs), affecting various cellular functions. These interactions with cell membrane receptors contribute to the therapeutic effects of plant-derived compounds (AL Zahrani *et al.*, 2020; Kale *et al.*, 2008; Williams & Spencer, 2012).

Regulation of Gene Expression: Certain plant-derived compounds can regulate gene expression, modulating the production of specific proteins and influencing cellular processes. For example, sulforaphane, derived from cruciferous vegetables like broccoli (*Brassica oleracea*), can induce the production of antioxidant and detoxifying enzymes by activating the Nrf2 pathway (Kensler *et al.*, 2013). Epigallocatechin gallate (EGCG), abundant in green tea (*Camellia sinensis*), has been shown to modulate gene expression involved in cancer cell growth and survival (Siddiqui *et al.,* 2004). By regulating gene expression, plant-derived compounds can impact cellular function and health outcomes.

Synergistic Effects of Compound Combinations: Medicinal plants often contain multiple bioactive compounds that can work synergistically, enhancing their therapeutic effects. This phenomenon is commonly observed in traditional herbal remedies. For example, the combination of curcumin and piperine from black pepper (Piper nigrum) has been shown to increase the bioavailability and effectiveness of curcumin (Shoba *et al.*, 1998). The synergistic effects of compound combinations can result in improved efficacy and a broader spectrum of therapeutic actions.

Potential for Drug Interactions and Adverse Effects: Medicinal plants and their compounds can interact with conventional drugs, affecting their absorption, metabolism, and elimination from the body. These interactions can lead to altered drug efficacy or increased risk of adverse effects. For instance, St. John's wort (*Hypericum perforatum*) induces the expression of drug-metabolizing enzymes, potentially reducing the effectiveness of certain medications (Gurley *et al.,* 2012). It is important to consider potential drug interactions and adverse effects when using medicinal plants alongside conventional therapies.

THERAPEUTIC APPLICATIONS OF MEDICINAL PLANTS

Medicinal plants have been used for centuries across different cultures and are recognized for their therapeutic applications. Traditional knowledge, combined with modern scientific research, has revealed the effectiveness of these plants in treating various diseases. They have played a significant role in traditional medicine systems including Traditional Chinese Medicine, Ayurveda, and Indigenous methods for healing. The traditional uses of medicinal plants provide valuable insights into their potential applications in promoting health and treating ailments. (Ahmad Khan & Ahmad, 2019)

Numerous scientific studies have investigated the therapeutic efficacy of medicinal plants. For instance, studies have shown the effectiveness of St. John's wort (*Hypericum perforatum*) in the treatment of mild to moderate depression (Linde *et al.,* 2008). Similarly, the extract of saw palmetto (Serenoa repens) has demonstrated efficacy in managing lower urinary tract symptoms associated with benign prostatic hyperplasia (Tacklind *et al.,* 2012). These studies highlight the importance of scientific evidence in validating traditional uses and expanding the therapeutic applications of medicinal plants.

Medicinal plants with antimicrobial properties, making them useful in combating infectious diseases. Many plant compounds exhibit anti-bacterial, anti-viral, anti-fungal, and anti-parasiticactivities. For example, tea tree oil derived from Melaleuca alternifolia has shown significant anti-microbial effects against a wide range of microorganisms (Carson *et al.,* 2006). Garlic (*Allium sativum*) exhibits potent antimicrobial activity against both Gram-positive and Gram-negative bacteria (Naganawa *et al.,* 1996). The antimicrobial properties of medicinal plants provide potential therapeutic options in the management of infectious diseases.

Chronic inflammation plays a critical role in the pathogenesis of various diseases. Medicinal plants with anti-inflammatory properties offer potential therapeutic benefits. For instance, the anti-inflammatory effects of curcumin from turmeric (*Curcuma longa*) have been extensively studied (Gupta *et al.,* 2012). Boswellia serrata, commonly known as frankincense, possesses anti-inflammatory properties attributed to its active compounds, such as boswellic acids (Hamidpour *et al.,* 2013). These plant-based anti-inflammatory agents hold promise in the management of inflammatory conditions.

Medicinal plants have long been explored for their anticancer potential. Several plant-derived compounds have shown cytotoxic effects on cancer cells and the ability to inhibit tumour growth. For instance, paclitaxel derived from the Pacific yew tree (*Taxus brevifolia*) is used as a chemotherapy drug (Gibson *et al.,* 1993; K, 2012). Resveratrol, found in grapes and wine, exhibits anticancer effects through multiple mechanisms (Bishayee *et al.,* 2010; Salehi *et al.,* 2018). Understanding the mechanisms of action of plant-derived anticancer compounds is essential for the development of effective treatments.

Medicinal plants are often rich in antioxidants, which aid in neutralising toxic free radicals and reduce oxidative stress in the body. The antioxidant effects of plants contribute to their protective role against various chronic diseases, including cardiovascular disorders and neurodegenerative diseases. Green tea (*Camellia sinensis*) contains catechins with strong antioxidant properties (Siddiqui *et al.,* 2004). The antioxidant effects of medicinal plants are crucial in maintaining overall health and preventing oxidative damage.

Additionally, medicinal plants also exhibit immunomodulatory qualities, meaning they may regulate the immune system's response. These plants can modulate immune cell function, cytokine production, and immune signalling pathways. For example, Astragalus membranaceus has been traditionally used in Traditional Chinese Medicine for its immunomodulatory effects (Cho & Leung, 2007). Medicinal plants with immunomodulatory properties hold potential therapeutic implications in conditions related to immune dysregulation, such as autoimmune diseases and immunodeficiency disorders.

Medicinal plants provide valuable important compounds for drug development, with many conventional drugs originating from plant-based sources (Cragg & Newman, 2013). For example, aspirin, derived from willow bark (Salix spp.), is a well-known example (Mahdi, 2010). Medicinal plants offer diverse chemical constituents for the discovery of novel therapeutics. Advanced techniques like high-throughput screening and bioinformatics aid in identifying and optimizing bioactive compounds from these plants for drug development.

CHALLENGES IN THE USE OF MEDICINAL PLANTS

The use of medicinal plants faces challenges in ensuring quality control, preventing adulteration and contamination, promoting sustainable sourcing and conservation, protecting intellectual property rights, establishing standardized dosage guidelines, addressing limited scientific evidence, and implementing robust regulatory frameworks. These challenges require measures such as quality control, testing, sustainable practices, legal frameworks, research collaboration, and harmonized regulations to ensure the safe and effective utilization of medicinal plants. (Canter *et al.*, 2005; Kala *et al.*, 2006; Mamedov, 2012).

CONCLUSION

It was found by the study that the area's therapeutic plants are abundant in phytochemicals and minerals. The manufacturing of novel pharmaceuticals, nutraceuticals, and healthcare items can use a variety of medicinal plants. The medicinal plants contain several pharmacologically active phytochemicals that have been used to treat a range of illnesses. These medicinal plant species benefit from their anti-oxidant, anti-inflammatory, anti-bacterial, and anti-viral characteristics. Numerous therapeutic uses are possible thanks to the capability of figuring out element concentrations in plants. Rural inhabitants in the research area have a substantial amount of traditional knowledge about the use of plants to treat a range of human and animal ailments. To characterize the photochemistry that might be useful for the development of novel drugs, more research should be done.

AUTHORS CONTRIBUTIONS

All the authors have contributed equally to this manuscript.

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Chapter 7

BIOCHEMISTRY OF MUSHROOMS

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ABSTRACT

Mushrooms are a great source of secondary metabolites, polysaccharides, unsaturated fatty acids, minerals, and proteins. Details on the compositions and nutritional benefits of edible mushrooms were covered in this chapter. They contain various amounts of vitamins, minerals, terpenoids, phenolic compounds, lectins, proteins, nucleic acids, lipids, carbohydrates, and terpenoids. Mushrooms high in fat-soluble vitamins and ergo sterol are regarded to be the only vegetarian source of vitamin D. Unsaturated fatty acids are observed to predominate over saturated fatty acids in mushrooms, particularly palmitic acid, oleic acid, and linoleic acid, with a very low amount of linolenic fatty acids. Mushrooms are the ideal dietary item with high nutritional value because they contain such essential components. These substances can operate as immunomodulatory, anticarcinogenic, antiviral, antioxidant, and anti-inflammatory agents, among other therapeutic actions. Additionally, the influence of mushroom functional components on the sensory qualities and quality of more nutritious foods. Because edible mushrooms contain all the essential elements, regular use of them would provide appropriate protection.

KEYWORDS: Mushrooms, antioxidant, nutritional, protection, anticarcinogenic.

INTRODUCTION

A mushroom is a type of macro fungus that is large enough to be seen with the unaided eye and harvested by hand. Mushrooms belong to the Agaricaceae family. Mushroom varieties vary in terms of their colours, forms, surfaces, and behaviour (Ogidi *et al.,* 2020). They grow over soil or on their food sources, like decomposing wood, in a climate that is both damp and chilly. Of the estimated 1.5 million fungi, 14,000 identified species produce fruiting bodies large enough to be classified as mushrooms and of which at least 2000 species are edibles (Rahi & Malik, 2016). Cutting a plant produces edible mushrooms, and some start from seeds, however, development varies depending on the species. Some mushroom-like plants and oysters grow quickly compared to maitake and morels, which take time (Kumla *et al.,* 2020). Edible mushrooms are harvested in the wild or cultivated all over the world (Thu *et al.,* 2020). Mushrooms have long been utilised as foods, and they are frequently delicious and healthful (Vinceti *et al.,* 2013).

Moisture (85–95%), carbs (37–70%), protein (15–34.7%), fat (10%), minerals (6–10.9%), and nucleic acids (3–8%) are all present in mushrooms (Rahi & Malik, 2016). Additionally, a significant number of vitamins are present in it, including thiamine (1.4–2.2 mg %), riboflavin (6.7–9.0 mg %), nacin (60–63 mg %), biotin (0.6–7 mg %), ascorbic acid (92–144 mg %), pantothenic acid (21.1–33.3), and folic acid (1.2–1.4 mg/100 g on a dry weight basis) (Hossain *et al.*, 2007). Calcium, iron, manganese, magnesium, zinc, and selenium are among the minerals contained in mushrooms (Alam *et al.*, 2007). Mushrooms are regarded as a nutritious food with nutritional benefits since they contain nutrients potassium, iron, copper, zinc, and manganese, for example, are rich in their fruit bodies, as well as carbohydrates, fibre, protein, essential amino acids, unsaturated fatty acids, vitamins, and low calories (Sánchez, 2004).

Mushroom extracts and their secondary metabolites contain antioxidant, antibacterial, anticancer, anti-inflammatory, ant obesity, and immunomodulatory properties as a result of their biological effects. As a result, phytochemicals, nutritionists, and consumers are all fascinated by the phytochemical contents of mushrooms, which have been shown to benefit humans in terms of health promotion and disease risk reduction (Thu *et al.*, 2020). Bioactive substances obtained from mushrooms that are good for human health and have antiviral action against DNA and RNA viruses include carbohydrate-binding proteins, peptides, triterpenes, proteins, polysaccharides, enzymes, triterpenoids and polyphenolic compounds (Seo & Choi, 2021).

Therefore, the purpose of this chapter is to give a general overview of the biochemistry, therapeutic applications, and processes based on the principle of mushroom secondary metabolites as well as their benefits and drawbacks. This chapter will also highlight typical issues and solutions. Only a few categories and compounds are shown because there are millions of natural products generated from mushrooms that are known.

CHEMICALS IN MUSHROOMS

PHENOLIC COMPOUNDS

Phenolic chemicals are aromatic hydroxylated compounds that contain one or more aromatic rings and hydroxyl groups. The presence of phenolic substances such as hydroxybenzoic acids, phenolic acids, lignans, tannins, hydroxy cinnamic acids, flavonoids, stilbenes, and oxidised polyphenols has been linked to the anti-inflammatory activities of several mushrooms (Côté *et al.*, 2010; D'Archivio *et al.*, 2010). Scientific studies have demonstrated that phenolic compounds have antifree radical, peroxide decomposer, metal activator, and oxygen scavenging properties. The phenolic compounds in mushrooms have antioxidant properties in addition to being an anticancer agent, as they have been shown to inhibit the growth of cancer cells by inhibiting lipopolysaccharide (LPS)-stimulated nitric oxide, as well as other anticancer mechanisms, such as the activation of programmed cell death and inhibition of mediated reactive oxygen species activity in the NF-B pathway (Venturella *et al.*, 2021). Edible mushrooms do not contain trans unsaturated fatty acids in general, but they do contain ergo sterol, which is used to prevent cardiovascular disease and is a source for the production of vitamin D (Javed *et al.*, 2019). Tocopherols are another form of fatty acid that has been discovered and is a powerful antioxidant in terms of free radical scavenging, therefore it helps to protect the heart (Kany *et al.*, 2019). Linoleic acid is well-known for its antioxidant function, which it does through blocking the synthesis of nitrous monoxide, tumour necrosis factor, interleukin-6, and interleukin-1. As a result of its inhibitory effect against acetylcholinesterase and butyrylcholinesterase, it is used in the treatment of Alzheimer's disease (Younis *et al.*, 2019).

The presence of 1-6 mg of phenolics/g of dried mushroom in *Agaricus bisporus, Boletus edulis, Calocybe gambosa, Cantharellus cibarius, Craterellus cornucopioides, Hygrophorus marzuolus, Lactarius deliciosus*, and *Pleurotus ostreatus*, and flavonoid concentrations varied from 0.9 to 3.0 mg/g. Catechin and myricetin were the two most abundant flavonoids. The highest levels of phenolic compounds were found in *B. edulis* and *A. bisporus*, whereas L. deliciosus had a high level of flavonoids and *A. bisporus, P. ostreatus*, and *C. gambosa* had low levels (Palacios *et al.*, 2011).

NUTRITIONAL VALUES OF MUSHROOMS

Edible mushrooms have been widely used as human food for millennia and are valued for their texture, flavour, as well as medicinal and tonic properties (Manzi *et al.*, 2001). Mushrooms typically consist of 90% water and 10% dry matter (Sánchez, 2010). They have a chemical composition that is appealing in terms of nutrition (Abdurrahman Dundar, 2008). Mushrooms are nutritionally significant since they are high in protein, fibre, and minerals while being low in fat. Because of their great digestion, mushrooms are being examined as a potential replacement for muscle protein (Kalač, 2009). Additionally, mushrooms are a good source of nutrients like phosphorus and iron as well as vitamins like thiamine, riboflavin, ascorbic acid, ergosterol, and niacin. They are also a rich source of vitamins B1, B2, B12, C, D, and E (Barros *et al.*, 2008). Mushrooms are also a good source of vitamin D, which is not found in other foods or supplements (Haytowitz & Pehrsson, 2018). Fruit bodies are high in minerals like potassium, iron, copper, zinc, and manganese. They also contain ash, glycosides, volatile oils, carotenoids, flavonoids, tocopherols, phenolic compounds, folates, organic acids, and other substances (Sánchez, 2010). Mushrooms are also advantageous in terms of nutraceuticals because they include a variety of components such as ascorbic acid, unsaturated fatty acids, tocopherols, phenolic compounds, and carotenoids. The nutrient content of edible mushrooms varies based on the growth and harvest stages, as well as the environment in which they are grown (Bellettini *et al.*, 2019).

PROTEINS

The crude protein content of edible mushrooms is typically high, but it varies substantially depending on factors such as species and stage of development (Longvah & Deosthale, 1998). Mushrooms are a good source of protein, with 200 to 250 grams per kilogramme of dry weight. Leucine, aspartic acid, valine, glutamine, and glutamic acid are the most frequent amino acids found in mushrooms. Due to the effective distribution of both essential and non-essential amino acids, particularly gamma-aminobutyric acid (GABA), a crucial neurotransmitter, the proteins of the Pleurotus species of mushroom have higher standards (Thu *et al.*, 2020). Numerous studies have demonstrated that mushrooms contain a high concentration of crude protein. The protein content of edible mushrooms ranged from 6.60 to 36.87 g/100 g dry weight, with an average value of 23.80 g/100 g dry weight (Zhou *et al.*, 2020). Even though the entire fruiting body of a mushroom is typically ingested, it is worth noting that different portions of the mushroom have varying protein levels.

LIPIDS

Mushrooms are a low-calorie food with a low-fat content (4-6%) and no cholesterol. It has been reported that the lipid proportion per 100 g in fresh mushrooms of various species ranges from 1.75

to 15.5% in dried mushrooms due to the high-water content of fresh mushrooms (Günç Ergönül *et al.,* 2013). The total fat content of A. bisporus has been found to be 1.66 to 2.2/100 g on a dry weight basis (Yilmaz *et al.,* 2006). Linoleic acid, oleic acid, and palmitic acid are the three most major fatty acids found in edible mushrooms.

CARBOHYDRATES

Edible mushrooms have a high carbohydrate content due to a high proportion of glucose and mannitol and a low proportion of sucrose and fructose (Pk *et al.,* 2020). Due to their nonstarch polysaccharides, mushrooms are a good source of dietary fibre. Mushroom stems are high in insoluble dietary fibres. Mushrooms have 4% to 9% soluble fibres and 22% to 30% insoluble fibres. The primary polysaccharide present in mushrooms is β--glucan, which also makes up around half of the bulk of the fungal cell wall. Many edible mushrooms have β-glucans that are responsible for their anticancer, immunomodulating, neuroprotective, anti-inflammatory, and antioxidant properties.

VITAMINS

The fruit body of the mushroom is rich in vitamins, including B1, B2, C, E, and D2. The most often seen B vitamins include cobalamin, pantothenic acid, folic acid, nicotinic acid, riboflavin, thiamine, and pyridoxine.

HEALTH BENEFIT OF EDIBLE MUSHROOM

Edible mushrooms have long been regarded as having tremendous health advantages. Mushroom biochemical components are responsible for numerous improvements in human health. Polysaccharides, low molecular weight proteins, glycoproteins, triterpenoids, and immunomodulating chemicals are among these bioactive substances. As a result, mushrooms have been found to boost immune function, improve health, lower the risk of cancer, prevent tumour growth, aid in blood sugar regulation, protect against inflammation, promote the body's detoxification processes, and combat germs, viruses, and fungi. Mushrooms are increasingly being recognized for their ability to supplement traditional treatments and to fight a variety of ailments (Ma *et al.,* 2018).

Antimicrobial Activity: Edible mushrooms have antibacterial properties due to high levels of phenols and alkaloids. Several studies have demonstrated that mushrooms are effective against many distinct strains of bacterial infections responsible for various diseases in people. L. delicious, S. imbricatus, and T. portentosum are some edible mushrooms with antibacterial properties (Chugh *et al.,* 2022). The exudate material extracted from the mycelium body of some mushroom species, on the other hand, is physiologically effective against plasmodium falciparum, the main cause of malaria transmitted by the female mosquito (Assemie & Abaya, 2022). Malaria is still the leading cause of death in children under the age of five in the majority of Sub-Saharan African countries.

Ganoderma pfeifferi extracts suppress the growth of bacteria that cause skin disorders. Oxalic acid has been identified as the component responsible for Lentinula edodes (Berk.)'s antibacterial activity against S. aureus along with other pathogens. L. edodes ethanolic mycelial extracts have antiprotozoal action against *Paramecium caudatum* (Kwak *et al.,* 2016).

Mushrooms that are edible have been proven to battle and kill a variety of bacteria. *L. sulphureous*, for example, is another form of edible mushroom that contains antibacterial flavonoid, lycopene, ascorbic acid and phenol. Secondary chemicals found in mushrooms, such as triterpene, are powerful antiviral agents, particularly for HIV. P. ostreatus has been found to be a broad-spectrum antibacterial agent (Barros *et al.,* 2008). *S. aureus, B. subtilis, Streptococcus mutants, Pseudomonas intermedia*, and *E. coli* have all been shown to be killed by mushroom extracts in chloroform and ethyl acetate (Gebreyohannes *et al.,* 2019).

Anticancer Activity: Studies have shown that edible mushrooms have anticancer action, particularly in cases of uterine, liver, breast, and pancreatic cancer (Patel & Goyal, 2012). This is due to the presence of secondary metabolites such as terpenoids, which have anticancer potential. In addition, the presence of P-glucan inhibits the growth of breast cancer cells. In one study, mushrooms were discovered to have cancer action in malignant liver cells by inhibiting tumour growth by preventing proliferation. Furthermore, mushrooms contain high levels of glucans, ranging from 0.21 to 0.53 grams per 100 grams of dry weight, since they constitute the majority of the fungal cell, and -glucans have been shown to possess cholesterol-lowering, anticancer and immune system-stimulating effects to combat cancer cells (Manzi & Pizzoferrato, 2000).

Antimutagenic Activity: Edible mushrooms contain biological substances that have antimutagenic and immune-modulatory properties. Among its bioactive substances, beta-glucan is a glucose residual backbone linked by a beta-1-3-glycosidic bond with an attached beta-1-6 branch point that has anticancer, immunomodulatory, and immune-stimulant activities (Caseiro *et al.,* 2022). Because of its immunomodulatory effect, it activates and boosts natural killer cells such as neutrophils, macrophages, T-cells, and B-cells, which lyse malignant cells (Hu *et al.,* 2019). In addition to anticancer action, mushroom polysaccharide extract has radical scavenging potential. About eight mushroom species have been studied, and their polysaccharide extract has anticancer action by scavenging free radicals that include superoxide and hydroxyl radicals (Chun *et al.,* 2021).

Antioxidant Activity: Due to the polysaccharides they contain, edible mushrooms are a good source of antioxidants. Studies have shown that mushrooms with phenolic extract have a lot of potential as antioxidants. Because they contain phenolic acid and other phenolic compounds in their methanol extract, mushrooms' fruiting bodies have the greatest antioxidant activity (Bach *et al.,* 2019). Among mushrooms, Gloeophyllum Sepiarium and Fomitotpispinicola exhibit high antioxidant activity. Some varieties of mushrooms also include beta-carotene and linoleic acid, which reduce auto-oxidation (Karácsonyi & Kuniak, 1994). Ergosterol, a precursor for the production of vitamin D and recognized for its potent antioxidant capabilities, is another substance found in mushrooms. According to research on methanolic extracts of black, red, and snow ear mushrooms, these plants have a strong reducing power and the capacity to chelate ferrous ions. They also have an inhibitory impact on lipid peroxidation and can scavenge DPPH and hydroxyl radicals. The antioxidant capabilities of various mushrooms, such *as H. erinaceus, T. giganteum, F. velutipes, L. edodes, D. indusiata, P. cystidiosus, G. frondosa, P. ostreatus*, and cylindracea, were also reported in investigations on those mushrooms (Mwangi *et al.,* 2022).

CONCLUSION

Mushrooms are essential resources for both food and medicine. Protein, carbs, amino acids, fatty acids, and vitamins are the most commonly found nutrients in mushrooms. By releasing antioxidants directly linked to many diseases, edible mushrooms have antibacterial capabilities that prevent and decrease numerous diseases. Anti-inflammatory, antioxidant, immunostimulatory, anticancer, antiviral, antibacterial, antifungal, hepatoprotective, antidiabetic, antiangiogenic, and hypoglycemia are only a few of the medicinal benefits of mushrooms. This would make it much easier to use edible mushrooms as functional food ingredients or products in the future that might provide people different health advantages.

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Chapter
8

LANDSCAPE HORTICULTURE

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ABSTRACT

Landscape horticulture, is an aesthetic branch of horticulture that involves the use of ornamental plants for the beautification of the landscape by the creation of gardens. The main objectives of landscaping are privacy, convenience, safety, comfort, ease of maintenance, and flexibility. It enhances the aesthetic appeal of the area and helps to harmonize the concrete architectural structure with nature. In the present chapter, a brief account of landscape horticulture has been taken to enlist landscaping principles and popularize the recent trends and practices in indoor and outdoor landscaping further ahead.

KEYWORDS: Landscape gardening, landscape architecture, plantscaping, interiorscaping, softscaping, holyscaping.

INTRODUCTION

Landscape horticulture, commonly known as landscaping or landscape gardening is an aesthetic branch of horticulture. In simple language, it refers to the beautification of land by the creation of gardens (Dipmala Kedar and Panchbhai, D., 2022). Landscape gardening is an outdoor activity and is defined as the application of ornamental plants, garden forms, styles, and elements to create a pictorial or naturalistic effect and thereby fulfilling aesthetic and functional purposes (Nambisan, 1992). It is based on the art and science of gardening which considers the overall environment and structure of the given land and shape it further using natural elements like landform, trees, shrubs, and water in a harmonized manner. The main objectives of landscaping are privacy, convenience, safety, comfort, ease of maintenance, and flexibility (Singh, 2020).

The professional who designs the landscape area is called a landscape designer or landscape architect. Since landscaping refers to mimicking nature, the landscape designer should be well-versed in ornamental planting, eco-gardening, plant morphology, physiology, architecture, and so on. (Landscape Gardening) He should be able to appreciate the beauty of plant forms, colour, texture, etc., and should be able to blend them well with concrete structures like buildings, roads, bungalows, resorts, etc. He should be able to overall improve the structure and functionality of the landscape for its better use and pleasure (Simonds, B. and Starke, J. O., 2010).

PRINCIPLES

There are two types of principles of landscape horticulture, viz., Primary and Secondary principles, which are as follows:

Primary Principles: These are the major principles to be adhered for effective landscaping. They are as follows:

A. To produce a 'Picture' in landscape: According to it, the house or building or the concrete structure forms the central figure of the picture which remains surrounded by the canvas of a lawn harmonized with plants. The plantation gives composition, colour, texture, and desired effect to the landscape. It generally involves formal styling of gardening (Landscape Gardening).

B. To produce natural or landscape effect: It is carried out by the method of mass planting as it involves a greater range for the display of plant forms, colours, textures, and patterns in a well-blended form. A well-blended and balanced form of a landscape always give a poetic, calming, soothing, refreshing, and energizing effect. It generally involves informal or free-styling of gardening (Landscape Gardening).

Secondary Principles: These are the subordinate principles, which serve as means and methods of making a picture or the naturalistic effect complete. These are the artistic principles. They are as follows:

- **Axis**: It is an imaginary divisional line, which divides the landscape into two sections. The axis should be artistic with a gentle curve and should harmonize with the backdrop. An axis can be directional, orderly, or dominating. It is presented in the form of a path, avenue, walkways, etc. The axis helps to connect different locations in the garden and thereby controls the movement in the garden. If the axis divides the garden into two equal parts, it is called a central axis. In a formal style, the axis is central whereas in an informal style, it is oblique (Singh, 2020).
- **Balance:** It is one of the most important principles. The imbalance in the garden distracts the attention of the viewer. Balancing both sides of the landscape around the axis is essential. The balance may be formal, informal, or symmetrical types. While creating balance in the landscapes, colour, texture, pattern, forms of the plants need to be considered (Landscape Gardening).
- **Circulation**: In landscape gardening, circulation becomes an important feature as it helps to connect the different parts of the garden. It refers to the avenue or pathway in the garden which helps the visitor to move in the garden from one place to the other and admire the beauty of the landscape by reaching its every corner (Landscape Gardening).
- **Colour**: The garden should not appear with patches of scattered colours. The continuity is maintained by a continuous green background. The flowering and colorful foliage plants are used to give a causal and incidental look in the landscapes and, also to create the colour and variety in the garden. More emphasis should be given to the position of the plants with reference to one another and to the structural design of the place rather than to the merits of an individual plant (Simonds, B. and Starke, J. O. , 2010).
- **Contrast**: In nature, contrast is very commonly reported. It helps to highlight the best features or locations in the garden. It is based on the colour - contrast theory. According to it, the contrasting coloured, textured or patterned plants, if planted together they make the landscape beautiful and attractive. If the contrasting elements of equal power are selected, they develop patchy, unpleasant landscapes. Therefore, one of the contrasting objects should be selected in such a way that it should dominate the other and becomes the main feature, while the other contrasting object should support the backdrop (e-Krishi Shiksha, 2011).

- **Focal point**: It is also known as emphasis or accent in the landscape. There should be at least one focal point per landscape. It helps to break the monotony of the garden and, also serves as the center of attraction. Mostly tall fountains, topiaries, trees, statues, etc. are used as focal points (Principles of Landscape Gardening).
- **Harmony**: Harmony forms the heart of the landscape. Well-blended and harmonized garden features, styles, textures, and colour contrasts help to create a pleasing pictural effect (e-Krishi Shiksha, 2011).
- **Mass Effect**: Mass effect can be achieved by planting one form of plant material in one place in a large number. Such arrangements help to give thickness and density to the landscape and help to make it prominent. However, care should be taken that the mass arrangements should not become repetitious and uninteresting (Raxworthy, J., 2018).
- **Mobility**: Mobility or movement can be set in the garden by wisely selecting forms and colours of the ornamentals. Seasonal plants show changes in their colours, forms, or flowering pattern and thereby set mobility or movement. The seasonal behaviour of the plants helps to create the movement of birds and butterflies in the landscape. Similarly, the fountains, water ponds, pools, and sprinklers also help to set movements in the garden (Bhattacharjee, 2004).
- **Proportion and scale**: Landscape designs erected with a proper proportions and accurate scale give pleasant look. This helps in effective space organization and management. Proportionately scaled avenues, paths, flowerbeds, lawns, hedges, edges always create harmonious effect (Nambisan, 1992).
- **Rhythm**: Rhythm refers to the repetition of the same object at equidistant level in the garden. It helps to create movement to the eye. Rhythm can be set by using the progression or the continuous line movement of a typical plant form with unique shape and size at regular intervals. Nowadays, the use of fountains, water canals, water strips, sprinklers, and lights are also in fashion to create the rhythm effects (Patel, 2018).
- **Space**: Effective space management is the key for the attractive, pleasant landscapes. This helps to appear the garden larger than its actual size. This can be achieved by the incorporation of large lawns and narrow paths in the setting of the landscapes (Principles of Landscape Gardening).
- **Style:** There are basically three styles of landscape gardening, viz., Formal, Informal and Free-style of gardening. The formal style is symmetrical and is based on geometrical designs. In it, the garden features exhibit geometrical shapes and patterns. These gardens primarily involve incorporation of fountains, water pools, water cannels, cascades, geometrically trimmed and trained shrubs, and trees in their setting, e.g., Persian and Moghal gardens. Informal style is the contrast of the formal style and imitates nature in its setting. It is based on asymmetrical pattern, in which the plants are allowed to grow in their natural forms. It is characterized by the incorporation of curved roads, bending paths, irregularly shaped flowerbeds, hillocks, and water bodies, e.g., Japanese gardens. Free-style of gardening is in between formal and informal type and involves combination of a few good features of both the styles, e.g., Rose Garden, Ludhiana (Landscape Gardening).
- **Symmetry**: It is associated with planning, clarity, rhythm, balance, and unity. Symmetrical garden plans are precise, detailed, and help to make attractive formal garden designs.

Asymmetrical plans lack maintenance of symmetry on both the sides of axis. However, overall balance, unity and harmony are maintained to develop informal and naturalistic garden designs (Nambisan, 1992).

- **Texture**: Like colour, texture is another equally important principle of landscaping. The texture of the ground, sand, pebbles, leaves, flowers, fruits etc. help to provide an overall textured effect to the landscape (Bhattacharjee, 2004).
- **Unity**: Landscape gardening is mainly based on the concept of 'Unity in diversity'. The landscape should never look patchy and discontinuous. The different sections of the garden which are consisting of different types of ornamentals should perfectly mix and match with each other and also harmonies well with the surroundings (Principles of Landscape Gardening).

INDOOR LANDSCAPING

Landscaping play an important role in blending the hardcore structures and spaces with the nature. Landscape gardening is mainly an outdoor activity; however, owing to its increasing popularity, it has also become a part of indoors for enhancing its aesthetics and functionality (Hammer, 1991). Indoor landscaping also known as 'Plantscaping' or 'Interiorscaping', is a practice of thoughtful and purposeful designing, installing, and maintaining greenery in and around the interiors for enhancing the plains, angles, and horizons of the indoor environment and making it green, serene, and pleasing (Mini, 2016). The extension of the landscape into the interiors makes it porous with green scapes and acts as a natural catalyst to set the ultimate connection between the interiors and nature. They maintain the microclimate of the interiors making it efficiently cooler or warmer as required and thereby reduce the strain on the energy consumption (Pliska, 2021). Thus, interiorscaping architecture plays a significant role in creating ecological urbanism with ecological buildings offering a clean, green, and holistic environment (Mehta, n.d.).

The common types of interiors caping are as follows:

- **Softscaping**: These are lush green gardens erected at indoor space with ample light and ventilation. Softscaping includes flowers, plants, shrubs, trees, and flower beds planted in movable containers. This type of landscape is advisable for bungalows, balconies, terraces, courtyards, passages, transition spaces, and room dividers. These are of high maintenance as they involve various garden operations like planting, trimming, watering, weed management, pest-disease control, etc (Hammer, 1991).
- **Stonescaping**: The stonescaping or stone gardens are an important part of Japanese landscapes and used all over the world to create similar ambience spaces. In it, the amount of green space is less and the space is mainly covered with various shape-forms of stones, tiles, sand, or pebbles. This type is ideal for entrance lobbies, courtyards, extended bedrooms, and meditation zones. It is a low-maintenance alternative to green gardens (Pliska, 2021).
- **Waterscaping**: Waterscapes are used to set a feeling of motion in the interiors. There are generally small ponds or channels of water added with suitable plantations and pebbles. These can also be erected in the form of small indoor waterfalls or vertical water walls in living rooms, dining areas, lobbies, passages, restaurants, and in meditation centres (Rukshana, 2021).
- **Vertical walls**: These are also known as vertical gardens, green walls, living walls, or eco walls. They are green installations grown vertically using hydroponics or drip irrigation. They have

become an integral part of modern indoor landscaping, contributing to eco-urbanism (Mehta, n.d.).

- **Floating indoor landscapes**: These are floating landscapes with a small water body surrounded by a small patch of lawn and ornamentals. Such floating garden is a visual delight offering habitat to aesthetic water flora like lilies and lotus and fauna like fishes, frogs, and turtles. These are used to create relaxing soothing ambience near the living room or dining areas (Mehta, n.d.).
- **Holyscapeing**: These are designed to create perfect holy ambience by installing a statue of the God, Goddess, scriptures surrounded by holy plants like basil (Tulsi), lotus, jasmine (Mogra), star jasmine (Kunda), Indian magnolia (Champa), and lotus. These gardens are believed to get good luck and positivity for the indoors (Mini, 2016).
- **Micro-farming**: It refers to farming at a very micro level. It is similar to softscaping, however; overhear, the plants are not just grown for beautification but are actually harvested as a source of food and medicine. A variety of indoor crops like vegetables, flowers, herbs and medicinal plants can be farmed and harvested (Rukshana, 2021).

IMPORTANCE

Landscape gardening enhances the aesthetic appeal of the area and thereby also helps to increase the property value. It helps to harmonize the concrete architectural structure with nature. It provides privacy and shelter around architectural creations. Landscaping is an effective way of land management and protecting it from getting converted into barren land or a garbage dumping ground (Dipmala and Panchbhai, 2022). It creates recreational grounds which help the visitors to relax and interact. It provides a home and shelter to various microorganisms, insects, birds, animals, etc., and thereby helps to conserve biodiversity. It provides hobby activities for homeowners, armatures, and people of all ages. It prevents soil erosion and, also helps in mineral recycling in soil. It helps to reduce air and noise pollution as the plants act as effective air purifiers and sound barriers (Patel, 2018). Besides providing environmental benefits, landscaping is also serving for the physical and mental health of mankind. Therefore, it has become an integral part of home construction and interior decoration (Rukshana, 2021). The commercial facilities, public areas, Malls, commercial facilities, public areas, playgrounds, parks, and so on are also landscaped appropriately to enhance its environment aesthetically and, also to make it more functional.

CONCLUSION

In today's world of stress and competition, landscape gardening helps to maintain a healthy mind and body. Besides, it has become an integral part of sustainable development as it smoothly blends technology with nature. It plays a vital role in environmental protection, conservation, and enhancement. Therefore, it can be said that eco-urbanism through effective landscape architecting would be the apt solution for mitigating the environmental crises caused by the rapid urbanization.

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Chapter 9

ETHNOMEDICINAL APPLICATIONS OF PLANTS USED BY THE TRADITIONAL HEALERS FROM THE WESTERN GHATS, INDIA: AN OVERVIEW

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ABSTRACT

During the last few decades there has been an increasing interest in the study of medicinal plants and their traditional use in different parts of India. Present study reviewed the indigenous knowledge about ethnomedicinal applications of plants used by the traditional healers from the Western Ghats. The study showed that a good number of the collected plants were used for the treatment of multiple diseases. Further research on the medicinal plants mentioned in this study might provide some potential leads to fulfill the needs of search for bioactive compounds and the discovery of new drugs to fight diseases.

KEYWORDS: medicinal plants, ethnomedicinal, bioactive compounds, Western Ghats.

INTRODUCTION

Knowledge of useful plants must have been the first acquired by man to satisfy his hunger, heal his wounds and treat various ailments (Kshirsagar and Singh, 2001). According to the World Health Organization (WHO) about 65–80% of the world's population in developing countries depends essentially on plants for their primary healthcare due to poverty and lack of access to modern medicine (Calixto, 2005). In recent years, use of ethnobotanical information in medicinal plant research has gained considerable attention in segments of the scientific community (Heinrich, 2000).

India has medicinal plants distributed in different geographical and environmental conditions (Chandler *et al.,* 1979 and Katewa, 2009). India includes elements of three biodiversity hotspots (Himalaya, Western Ghats, and Indo-Burma) that are highly endangered ecoregions (Myers *et al.*, 2000 and Sajem *et al.,* 2008). In India, at least 2500 plants, out of 18,000 recorded in the country are utilized for medicinal purposes (Anyinam, 1995).

During the last few decades there has been an increasing interest in the study of medicinal plants and their traditional use in different parts of India. Unfortunately, recent decades have seen significant changes occurring within several aspects of ethnomedicine as a result of environmental degradation and tremendous changes in modern, social, and economic systems (Anyinam, 1995; Rai and Lalramnghinglova 2010). Therefore, the present study provides an overview on ethnomedicinal applications of plants used by the traditional healers from the Western Ghats of India.

DESCRIPTION OF STUDY AREA

Western Ghats of India stretches from a latitudinal extent of 8°–22°N along a 1500 km in length from river Tapti in North to Kanyakumari in South. The mean elevation of the Western Ghats is higher than 600 m and exceeds 2000 m at some places. It covers parts of six states, viz., Gujarat, Maharashtra, Karnataka, Goa, Kerala and Tamil Nadu and one union territory (Dadra and Nagar Haveli) (Figure No. 1) (Reddy *et al.,* 2016). Among the hotspots under India, the Western Ghats account for 64.95%, Indo-Burma for 5.13%, Himalaya for 44.37% and Sundaland for 1.28%. It contains more than 30% of all plant and vertebrate species found in India, in less than 6% of the country's landmass. There are 8,080 taxa of flowering plants known from the Western Ghats including 5588 indigenous species (Nayar *et al.,* 2014). The Western Ghats of Karnataka represents highest forest cover (37.4%), followed by Maharashtra (25.9%), Kerala (17%), Tamil Nadu (13.6%), Gujarat (3.9%) and Goa (2%).

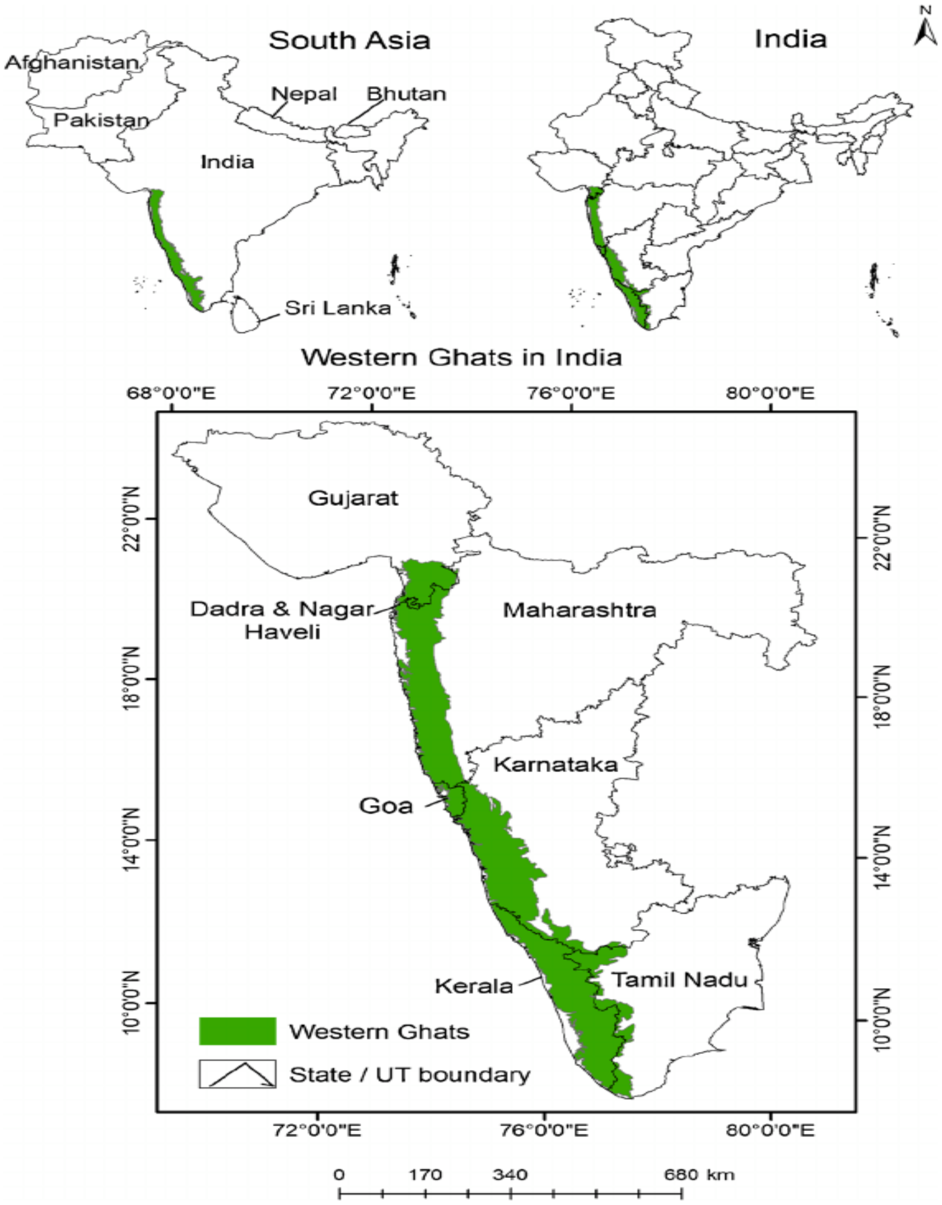

Fig. 1: Location map of Western Ghats (Reddy *et al.,* 2016)

ETHNOMEDICINAL APPLICATIONS OF PLANTS

The present review documented ethnomedicinal applications of plants used by the traditional healers from Karnataka, Maharashtra, Kerala and Tamil Nadu states which cover major forest cover of the Western Ghats (Plate No. 1, and Table No.1).

ETHNOMEDICINAL PLANTS FROM KARNATAKA

In the Dharwad district of Karnataka in Southern India 35 plants belonging to 26 families are being used to treat different types of oral ailments (Hebbar *et al.*, 2004). Study by Bhat *et al.*, (2012) resulted in recording of 106 medicinal plant species of 55 families and 86 formulations to treat different types of wounds practiced in different communities of Uttara Kannada district of Karnataka. Among the 106 plants recorded four species are endemic to India and 22 species have the nativity outside India. Rest of the species have nativity both in India and elsewhere.

ETHNOMEDICINAL PLANTS FROM MAHARASHTRA

About 2242 medicinal plants have been recorded from the state of Maharashtra (Kareem, 1997). The documented ethnomedicinal plants in Maharashtra were mostly used to treat skin disorders, diarrhea, jaundice, tuberculosis, stroke, migraine, menstrual problems, fertility problems, urinary problems, piles, wounds and poisonous bites (Jagtap *et al.*, 2006). Ethnobotanical survey of Thane district documented 34 species, 32 genera members of 30 families used to cure various ailments (Khan, 2013).

ETHNOMEDICINAL PLANTS FROM KERALA

A total number of 146 species of plants distributed in 122 genera belonging to 58 families were identified as commonly used ethnomedicinal plants by Irula tribes of Walayar valley of Southern Western Ghats (Venkatachalapathi *et al.*, 2018). A total of 102 species of plants distributed in 95 genera belonging to 53 families were identified as commonly used ethnomedicinal plants by traditional healers in silent valley for the treatment of 19 ailment categories based on the body systems treated (Morvin Yabesh *et al.*, 2014).

ETHNOMEDICINAL PLANTS FROM TAMIL NADU

An ethnobotanical survey was carried out among the ethnic groups (Kani/Kanikaran) in Southern Western Ghats (Ayyanar and Ignacimuthu, 2005; Hebbar *et al.*, 2004; Mahishi *et al.*, 2005). Traditional uses of 54 plant species belonging to 26 families are described under this study (Ayyanar and Ignacimuthu, 2005). A total of 101 species of plants are used by Paliyar tribals in Theni district of Tamil Nadu, belonging to 90 genera and 48 families. These were reported with the help of standardized questionnaires among 15 tribal informants (Ignacimuthu *et al.*, 2008).

Plate 1: Plant species used by the traditional healers from the Western Ghats
(https://indiabiodiversity.org& Jambilkar *et al.,* 2021)

1. ***Abutilon indicum***

2. ***Alstonia scholaris***

3. ***Careya arborea***

4. ***Cordia dichotoma***

5. ***Erythrina variegata***

6. ***Gloriosa superba***

7. ***Leea asiatica***

8. ***Madhuca longifolia***

9. ***Plumeria rubra***

10. ***Semecarpus anacardium***

11. ***Syzygium cumini***

12. ***Tinospora cordifolia***

Table 1: List of some common plant species used by the traditional healers from the Western Ghats

Sr. No.	Botanical Name	Family	Vernacular/local Name/s	Plant part/s used	Ethnomedicinal uses (References)
1	*Abutilon indicum* (L.) Sweet.	Malvaceae	Mudre gida (Indian mallow)	L, Fr	Piles (Rajakumar and Shivanna, 2009), dysentery, diarrhea (Parthiban *et al.*, 2016)
2	*Achyranthes aspera* L.	Amaranthaceae	Uttarani (Prickly chaff flower)	W, R	Cuts, gingival wounds (Bhat *et al.*, 2012), Gastric problems (Rajakumar and Shivanna, 2009), fever (Kasarkar *et al.*, 2014)
3	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Maddale (Devil tree)	B	Fever (Rajakumar and Shivanna, 2009), cuts (Bhat *et al.*, 2012)
4	*Alternanthera sessilis* (L.) R. Br. ex DC.	Amaranthaceae	Agrada kudi	W, L	Aphthae (Bhat *et al.*, 2012), Stomachache (Rajakumar and Shivanna, 2009)
5	*Aristolochia indica* L.	Aristolochiaceae	Eswariballi (The Indian Birthwort)	L	Skin allergies (Rajakumar and Shivanna, 2009)
6	*Barleria prionitis* L.	Acanthaceae	Arisina Gentige	L	Gingival wounds (Bhat *et al.*, 2012)
7	*Barringtonia racemosa* (L.)	Barringtoniaceae	Samudraphala, Nanjina mara	Fr	Dog bite (Bhat *et al.*, 2012)
8	*Butea monosperma* (Lam.) Taubert.	Fabaceae	Muttuga (Flame of the forest)	B, Fl	Urinary infection (Rajakumar and Shivanna, 2009), gastric problems (Kasarkar *et al.*, 2014)
9	*Calotropis gigantea* (L.) R.	Asclepiadaceae	Ekke	R	Gingival wounds, Otorrhoea, Scorpion bite, Snake bite (Bhat *et al.*, 2012)
10	*Careya arborea* Roxb.	Lecythidaceae	Koulu	B	Aphthae, ulcer in intestine (Bhat *et al.*, 2012), dysentery (Rajakumar and Shivanna, 2009)
11	*Clitoria ternatea* L.	Fabaceae	Bili Shankhapushpa	R	Otorrhoea (Bhat *et al.*, 2012), Cholera (Rajakumar and Shivanna, 2009)

12	*Cordia dichotoma* Forst.	Boraginaceae	Bhokar	Fl	Menstrual disorders (Jagtap *et al.,* 2006)
13	*Cuminum cyminum* L.	Apiaceae	Jirige (Cumin)	S	Body heat (Rajakumar and Shivanna, 2009), Aphthae, ulcer in intestine, gangrene, gingival wounds (Bhat *et al.,* 2012)
14	*Cynodon dactylon* Pers.	Poaceae	Arugan	L, W	Increasing lactation, conjuctivitis (Parthiban *et al.,* 2016), Sore nose (Bhat *et al.,* 2012), indigestion and stomach ache (Venkatachalapathi *et al.,* 2018)
15	*Dendranthema indicum* (L.)	Asteraceae	Sevantige	L	Cuts (Bhat *et al.,* 2012)
16	*Emblica officinalis* Gaertn. Fract.	Euphorbiaceae	Awala	Fr	Vomiting (Kasarkar *et al.,* 2014)
17	*Ensete superbum* (Roxb.) Cheesman (syn. Musa superba Roxb.)	Musaceae	Kallubale (Wild platain)	S	Appendicitis (Rajakumar and Shivanna, 2009), Child birth (Jagtap *et al.,* 2006)
18	*Erythrina variegata* L.	Papilionaceae	Halavana (Indian coral tree)	L	Toothache (Rajakumar and Shivanna, 2009), cough and cold (Venkatachalapathi *et al.,* 2018)
19	*Ferula assa-foetida* L.	Apiaceae	Hingu (Asafoetida)	R	Stomachache (Rajakumar and Shivanna, 2009)
20	*Ficus racemosa* L. (syn. Ficus glomerata Roxb.)	Moraceae	Atthi (Udumbara)	Fr	Leucorrhoea (Rajakumar and Shivanna, 2009; Revathi *et al.,* 2013)
21	*Ficus religiosa* L.	Moraceae	Arasam	L	Tonsils problems (Parthiban *et al.,* 2016), skin allergies (Rajakumar and Shivanna, 2009)
22	*Gliricidia sepium* L.	Fabaceae	Giripushpa	L	Ring worm (Rajakumar and Shivanna, 2009)

23	*Gloriosa superba* L.	Liliaceae	Zagdaili	R	Prolapse of cattle (Jagtap *et al.,* 2006), abortion (Venkatachalapathi *et al.,* 2018)
24	*Glycyrrhiza glabra* L.	Papilionaceae	Jhestamadhu (Liquorice)	R	Asthama (Rajakumar and Shivanna, 2009), cuts (Bhat *et al.,* 2012)
25	*Hemidesmus indicus* (L.) W. T. Aiton.	Asclepiadaceae	Sogade (Indian Sarsaparilla)	R	Diabetes (Rajakumar and Shivanna, 2009), blood purification (Xavier *et al.,* 2014).
26	*Holarrhena pubescens* (Buch.-Ham.) Wall. ex. G. Don.	Apocynaceae	Kodasiga (Kutaja)	R, B	Ring worm (Rajakumar and Shivanna, 2009), Aphthae, ulcer in intestine (Bhat *et al.,* 2012)
27	*Lantana camara* L.	Verbenaceae	Bendele	L	Cuts (Bhat *et al.,* 2012; Rajakumar and Shivanna, 2009)
28	*Leea asiatica* (L.)	Leeaceae	Bili Nedtige	R	Burn (Bhat *et al.,* 2012)
29	*Leucas aspera* (Willd.) Link.	Lamiaceae	Thumabi	R, L	Snake bite (Revathi *et al.,* 2013), wound, eye infection (Rajakumar and Shivanna, 2009)
30	*Madhuca longifolia var. latifolia* (Roxb.) Chev.	Sapotaceae	Mu	L	Stroke (Jagtap *et al.,* 2006), fever (Parthiban *et al.,* 2016)
31	*Melia azedarach* L.	Meliaceae	Arebevu (Bead tree)		Menstrual problems (Rajakumar and Shivanna, 2009), mangemites (Parthiban *et al.,* 2016)
32	*Murraya koenigii* (L). Spreng.	Rutaceae	Karivaeppilai	L	Repeat bleeding problem (Parthiban *et al.,* 2016), diabetes (Kasarkar *et al.,* 2014)
33	*Plumeria rubra* L.	Apocynaceae	Govesampige	B	Gingival wounds, snake bite (Bhat *et al.,* 2012), jaundice (Rajakumar and Shivanna, 2009)

34	*Pongamia pinnata* L.	Fabaceae	Pungam	S, B	Rheumatism (Venkatachalapathi *et al.*, 2018), Snake bite (Bhat *et al.*, 2012; Revathi *et al.*, 2013), diabetes, eczema (Revathi *et al.*, 2013), blood purification (Kasarkar *et al.*, 2014)
35	*Rauvolfia serpentina* (L.) Benth.	Apocynaceae	Amalpori	L	Snakebite (Venkatachalapathi *et al.*, 2018; Bhat *et al.*, 2012)), Otorrhoea, scorpion (Bhat *et al.*, 2012)
36	*Ruta graveolens* L.	Rutaceae	Sadapu (Garden Rue)	L	Cough and cold (Rajakumar and Shivanna, 2009)
37	*Semecarpus anacardium* L.	Anacardiaceae	Bibba	Fr	Crack foot (Bhat *et al.*, 2012)
38	*Syzygium cumini* (L.) Skeels.	Myrtaceae	Nerale	B, L, Fr	Aphthae and ulcer in intestine (Bhat *et al.*, 2012), diabetes, dysentery (Venkatachalapathi *et al.*, 2018), skin problems (Roy *et al.*, 2020)
39	*Terminalia arjuna* W.and A.	Combretaceae	Arjun Sadad	Fr	Crack foot (Bhat *et al.*, 2012), chest pain (Venkatachalapathi *et al.*, 2018)
40	*Terminalia bellirica* (Gaertner) Roxb.	Combretaceae	Taar	B, Fr	Wounds with maggots in cattle (Bhat *et al.*, 2012), Psoriasis (Rajakumar and Shivanna, 2009), chest pain (Venkatachalapathi *et al.*, 2018)
41	*Terminalia chebula* Retz.	Combretaceae	Anale	Fr	Inter trigo, Otorrhoea (Bhat *et al.*, 2012), stomach pain (Venkatachalapathi *et al.*, 2018)
42	*Tinospora cordifolia* (Willd.) Hook. F. and Thomson.	Menispermaceae	Amruthaballi (Gulancha)	L, S, W	Boils, blood pressure, diabetes, itching (Rajakumar and Shivanna, 2009), insomnia (Revathi *et al.*, 2013)

43	*Tridax procumbens* L.	Asteraceae	Mookuththi poo	L	Wound (Parthiban *et al.*, 2016), toothache (Rajakumar and Shivanna, 2009)
44	*Vitex negundo* L.	Verbenaceae	Nukki (Nirgundi)	L	Whitlow, wounds due to prickly heat, wounds with maggots (Bhat *et al.*, 2012), fever, pneumatic pain (Rajakumar and Shivanna, 2009)
45	*Zingiber officinale* Roscoe.	Zingiberaceae	Shunth	Rh	Aphthae, ulcer in intestine (Bhat *et al.*, 2012), Tympanites (Rajakumar and Shivanna, 2009)
Parts Used: W—whole plant, R—root, L—leaves, S—stem, B—bark, Fl—flower, Fr—fruit, Sd—seed, Rh—rhizome					

DISCUSSION

The knowledge on the folklore uses of the medicinal plants leads to open up ways for effective utilization of herbal medicines in future. Present study reviewed the indigenous knowledge about ethnomedicinal applications of plants used by the traditional healers from the Western Ghats. The study showed that a good number of the collected plants were used for the treatment of multiple diseases. Further research on the medicinal plants mentioned in this study might provide some potential leads to fulfill the needs of search for bioactive compounds and the discovery of new drugs to fight diseases.

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Chapter
10

THERAPEUTIC GARDENING

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ABSTRACT

Therapeutic gardening is an old age practice which helped the people to get connected with nature. The idea has been revived now and has been used in health care sectors to treat persons with social, mental, and physical problems. It is a natural method to reduce stress, tension, fatigue, pain, sadness, depression and anxiety. It increases positive mood, energy and feeling of calm and encourage human-nature interactions. It is an inexpensive dose of nature therapy which would have a good effect on a wide range of physical and mental health issues. Therapeutic Gardens can be found in a variety of settings, including hospitals, skilled nursing homes, assisted living residences, continuing care retirement communities, outpatient cancer centres, hospice residences, and other related healthcare and residential environments.

KEYWORDS: Therapeutic gardening, hospice residences, assisted living residences.

INTRODUCTION

Technology, urbanisation and industrialization had undoubtedly made significant benefits to human population but they have been associated with increasing rates of anxiety, depression, and feelings of social isolation as well as increased prevalence of chronic illnesses (Hidaka 2012). Stress, anxiety, dementia, cancer, stroke, heart attack and other disease conditions are rising at an alarming rate in young and ageing population all over the world. Even when the best medical care is given to the patients, the services are costly and less effective with time because the drugs may have negative health impacts. In a hospital setting, the family members who care for the patients are likewise subjected to tremendous mental and physical suffering. According to studies, exposing people to the greenery and bright flowers of a garden can lower blood pressure and enhance both physical and mental health.

The American Horticultural Therapy Association (AHTA) defines a therapeutic garden as "a plant-dominated environment purposefully designed to facilitate interaction with the healing elements of nature (ATHA, 2017). It is a natural method to reduce stress, tension, fatigue, pain, sadness, depression and anxiety. It increases positive mood, energy and feeling of calm and encourage human-nature interactions (Sudati Akshitha, 2021). The definition of therapeutic horticulture is "the participation in horticultural activities facilitated by a registered horticultural therapist or other professionals with training in the use of horticulture as a therapeutic modality to support program goals. Therapeutic horticulture is the process through which participants enhance their well-being through active or passive involvement in plant and plant-related activities" (AHTA, 2017).

HISTORY OF THERAPEUTIC GARDENS

Simson and Straus (1998) reported that the first recorded use of horticulture for therapy occurred in ancient Egypt, when walking in palace gardens was prescribed for mentally disturbed royalty. Following that during 18th and 19th centuries many countries such as France (Flahive-DiNardo *et al.* 2013), Europe, US and UK adopted the green therapy for treatment in mental health clinical settings. In 1812, Dr. Benjamin Rush, father of American psychology, published findings on the positive therapeutic relationship between gardening and better recovery rates in patients diagnosed with mania (Simson and Straus 1998). Between 1914 and 1944, the use of horticulture to improve the care of veterans advanced significantly during World War I. The enormous number of returning wounded veterans to US hospitals precipitated the start of horticulture use in the clinical settings.

Initially, horticulture was used for occupational and recreational therapy as part of psychiatric rehabilitation (Simson and Straus, 1998). Dr. Benjamin Rush discovered that outdoor work in a farm setting helped attain positive outcomes for clients with mental illness (Simson& Straus, 2003). As a result of this many hospitals in the western world started adopting horticulture as a therapeutic treatment method for patients with mental health and developmental disabilities. In an effort to aid patients in their recovery, Friends Hospital (Asylum for Persons Deprived of Their Reason) built an environment with landscaping, walkways, and a park atmosphere in 1817. In 1879 Friends Hospital built the first greenhouse that was used for therapy (Simson& Straus, 2003). Plants and gardening also came to be used as a diversion for those who were hospitalized long-term. Persian garden, the Japanese Zen Garden and the Monastic Cloister gardens are some of examples of a healing environment which appeared throughout history in different parts of the world. The Greeks created healing temples for their gods. Aesclepius, the god of healing, had a temple built for him in a pastoral area that had mineral springs, swimming pools, gyms, and healing gardens. Here people would come to worship, lodge, recreate, and heal. In 1972 the Menninger Foundation teamed with the Horticulture Department at Kansas State University to provide training for undergraduate students in the mental health field. This would lead to the first horticultural therapy curriculum in the US. Therapeutic Gardens can be found in a variety of settings, including hospitals, skilled nursing homes, assisted living residences, continuing care retirement communities, outpatient cancer centres, hospice residences, and other related healthcare and residential environments (Sudati Akshitha, 2021).

TYPES OF THERAPEUTIC GARDENS

Decreased stress and an increased sense of well-being are among the most commonly reported benefits of therapeutic gardening (AHTA 2017; Simson and Straus 1998). Different types of therapeutic gardens are as follows:

1. Memory gardens / Alzheimer's Gardens - Adult day care programs and dementia residences.
2. Healing Gardens/ Cancer gardens –Acute care hospitals, skilled nursing facilities and other healthcare and chemotherapy facilities.
3. Rehabilitation Gardens - Rehabilitation hospitals.
4. Restorative Gardens –Psychiatric hospitals.
5. Senior Community Gardens - Assisted living, continuing care retirement communities and other senior living residences.
6. Enabling Gardens – Vocational schools and arboretum.

7. Sensory gardens – Outpatient Clinics, schools, dementia centres use sensory gardens.
8. Meditation Gardens - Religious institutions and other faith-based settings.

(Gigliotti and Jarrott, 2005; Joyce and Warren 2016; Lidén *et al.*, 2016; Page 2008; Simson and Straus 1998, Sudati Akshitha, 2021).

BENEFITS OF THERAPEUTIC GARDENS

Physical benefits - Promote physical health, improving the immune response, reducing the heart rate, stress and tension, improving physical movement skills between hand and eye.

Psychological benefits - Reducing stress, improving mood, improving the quality of life, increased self-confidence, improved sense of well-being, pride and achievement, ownership, calm, relaxation, stability, increased self-esteem, improving personal satisfaction, reducing anxiety and alleviating depression.

Social benefits - Improving social integration, increased social interaction, providing a healthy environment for teamwork, improving group cohesion.

Cognitive benefits - Enhancement of cognitive performance, improve focus, improving the ability to pay attention, achieving goals, activating the memory.

Economic benefits- Reducing recovery time, reducing the quantities of medicines needed to treat patients, minimizing healthcare costs, improving job satisfaction, and general health, and reduces the stress of the workforce, interaction with nature encourages a holistic/environmental approach to health.

Environmental benefits - Increasing the preservation of green spaces, improving the natural values inside the gardens.

Spiritual benefits - Feeling of freedom and stimulating a sense of humility, motivation to have different points of view, connecting with nature can inspire feelings of peace, unity, connectedness and strength, provide spiritual inspiration, contact with nature can reduce hallucinations and drug abuse (Alkaisi *et al.*, 2021).

REVIEW OF CASE STUDIES

The promising effect of gardening on improvement of mental and physical health has been studied and practised internationally. In a study conducted by Japasense, viewing plants altered EEG recordings and reduced stress, fear, anger and sadness, as well as reducing blood pressure, pulse rate and muscle tension (Nakamura and Fujii, 1990). According to another study by environmental psychologist Ulrich (1984), views of plants and trees from post-operative wards improved the mood of patients, and reduced analgesic use, surgical complications and length of stay. Viewing natural scenes together with natural sounds improved the experience of bronchoscopy (Diette *et al.* 2003). Hefferman *et al.* (1995) reported that viewing sculpture gardens without any greenery through the windows of an oncology ward caused a negative reaction in many patients. Even randomly exposing post-operative patients to pictures of countryside on the walls of their rooms can reduce pain and anxiety (Ulrich *et al.*, 1993).

Residents of a prison in Michigan used the prison medical services less frequently than those who had an internal courtyard view from their cells (Moore, 1981). When post-operative patients were exposed to eight different species of indoor plants, both pain and length of stay were once again reduced and patients' satisfaction with their hospital rooms was improved (Park and Mattson, 2009). Exposing pictures of flowers in the dictator game, which is an economic game that questions whether individuals are solely driven by self-interest, can change the decisions made by the players (Raihani and Bshary, 2012). According to Lohr *et al.* (1996), putting plants in a computer room improved productivity and lowered blood pressure. Indoor gardening has been used to treat patients with mental health problems (Spring *et al.,* 2011). It is not only the appearance of plants that is beneficial: their leaves remove toxins, dust and microorganisms from the air (Perez *et al.,* 2013). Many studies in the UK and other countries concur that higher proportions of green space, especially bio diverse habitats, are associated with less depression, anxiety and stress, even after controlling for potential confounding factors such as deprivation (Beyer *et al.* 2014). In Japan, green space has been linked with increased longevity (Takano *et al.,* 2002). Interestingly, the benefit of green space may not be simply related to physical activity but might rely more on improved social interaction (Richardson *et al.,* 2013).

CONCLUSION

The therapeutic garden is an older idea that is currently being revitalized due to its extensive medical advantages. The importance of outdoor space is undeniable, and connection to nature is vital and beneficial. Gardening therapy has been used to treat persons with social, mental, and physical problems. It is a natural method to reduce stress, tension, fatigue, pain, sadness, depression and anxiety. It increases positive mood, energy and feeling of calm and encourage human-nature interactions. The progress in research investigations in the field of therapeutic gardening will support the development of evidence-based research and the continued application of best practices. An inexpensive dose of nature therapy would have a good effect on a wide range of physical and mental health issues. In recent decades, the atmosphere of hospitals and medical facilities has reduced to purely physical aspects, such as enclosed spaces removed from their natural surroundings. Given that India has the largest healthcare system in the world, there is more opportunity to invest in constructing green spaces and gardens for the benefit of patients and their families in order to help them overcome both physical and emotional problems. Such type of gardening can be practised in hospitals, nursing homes, old age homes, prisons and schools.

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Chapter 11

CULTIVATING CONFIDENCE: A COMPREHENSIVE JOURNEY INTO SEED CERTIFICATION AND THE VITAL ROLE OF CERTIFIED SEEDS IN INDIA

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ABSTRACT

Seed certification is critical in assuring the quality and integrity of agricultural seeds, thereby ensuring the core objective of sustainable agriculture. The procedure of certification verifies and attests the genetic purity, physical purity, and health of seeds. Through strict adherence to established standards and regulations, seed certification programs aim to maintain varietal identity, prevent the dissemination of harmful pathogens, and promote consistent and reliable crop performance. The significance of seed certification extends beyond national borders, as international trade heavily relies on the trustworthiness and credibility of certified seeds. This chapter outlines the fundamental processes involved in seed certification, including the production and maintenance of seed stocks, field inspections, laboratory testing, and seed labelling. It also elucidates the various classes that differentiate seeds based on their genetic purity and performance attributes. The classification encompasses classes such as "Breeder Seed," representing the highest genetic purity obtained from the original breeder; "Foundation Seed," derived from Breeder Seed and used for further multiplication; and "Certified Seed," which is the final product available to farmers for crop cultivation. Furthermore, the chapter examines the roles of different stakeholders, such as seed breeders, certifying agencies, and farmers, in the seed certification process. It highlights the collaboration and transparency necessary for effective implementation and enforcement of seed certification standards. These processes collectively ensure compliance with set quality criteria and establish traceability throughout the seed supply chain. Seed certification is an indispensable tool for ensuring the authenticity, quality, and safety of agricultural seeds. By upholding rigorous standards and meticulous processes, seed certification programs play a pivotal role in supporting global agricultural endeavours and achieving sustainable and resilient food systems.

KEYWORDS: Seed Certification, Genetic Purity, Breeder, Seed Standards, Supply Chain.

INTRODUCTION

Seed is an indispensable resource for a sustained growth in agriculture, and is one of the several elements essential for increasing crop yield and productivity. A competent framework is the fundamental requirement and primary step towards the country's food security and functions as a driver of commercial agricultural proliferation. The Indian seed sector has evolved gradually from a predominantly public sector in the 1960s to a multi-faceted industry with a significant number of private enterprises involved and an increased emphasis on research and development operations.

THE PRESENT CHAPTER PROVIDES AN OVERVIEW OF THE KEY SEED CERTIFICATION ASPECTS

1. **Seed Certification Agencies (SCAs):** Seed Certification Agencies (SCAs) at the state and central levels regulate the certification process. These organisations are in charge of examining, testing, and certifying seeds in accordance with established criteria.
2. **Seed Classes**: Seeds in India are classified into four categories based on their quality and genetic purity. Each category has its own set of rules and standards that must be satisfied.
3. **Certification Process:** Field inspections, seed sampling, laboratory testing, and documentation are all part of the certification process. SCAs evaluate crops in the field to ensure their identification, genetic purity, and field standards. To verify seed quality, germination potential, and disease-free status, seed samples are collected and sent to recognized laboratories for testing.
4. **Seed Standards**: In India, seed standards have been formed to lay out the minimum quality requirements for several crops. They include factors like genetic purity, physical purity, germination capacity, moisture content, and the absence of seed-borne illnesses. To be certified, seeds must fulfill these requirements.
5. **Certification Tags**: Seeds that fulfill the requirements are given a seed certification tag or mark. The certification mark signifies that the seeds have been inspected, tested, and certified.
6. **Seed Multiplication**: Certified seeds are the basis of subsequent seed multiplication. Certified seeds can be used by certified seed producers to produce foundation and certified seeds for distribution to farmers.
7. **Enforcement**: State Seed Certification Agencies (SSCAs) and Central Seed Certification Agencies (CSCAs) are in charge of enforcing seed certification standards and regulations. They carry out frequent inspections, collect samples, and take legal action against noncompliant seed producers.

SEED CERTIFICATION AGENCIES (SCAS)

The National Seed Certification Agency (NSCA) and State Seed Certification Agencies (SSCAs) play significant role in coordinating and overseeing seed certification activities. The roles and responsibilities of NSCA include:

a) **Coordination**: The NSCA serves as the national coordinating agency for seed certification initiatives and collaborates with the SSCAs to guarantee uniformity and adherence to the established seed certification standards and processes.
b) **Guideline formulations:** The NSCA formulates guidelines, standards, and processes for seed certification, encompassing various aspects such as physical purity, genetic purity, high seed quality, labelling, and documentation requirements.
c) **Training and Capacity Building**: The NSCA is involved in capacity building and training programs for seed certification personnel. It provides technical guidance, training workshops, and knowledge sharing to enhance the skills and competencies of seed certification professionals across the country.
d) **Field Inspections**: The NSCA conducts field inspections to assess the compliance of seed production areas with prescribed standards.
e) **Laboratory Testing and Quality Control**: The NSCA oversees the seed testing processes carried out by accredited seed testing laboratories. It ensures that proper seed testing methods and

quality control measures are followed to evaluate seed quality, germination capacity, moisture content, and freedom from seed-borne diseases.

f) **Certification Issuance**: The NSCA is responsible for the issuance of seed certification tags or marks. It evaluates the conformity of seed lots with the set standards and offers certification to those that do.

SEED CLASSES: THE SEEDS ARE CLASSIFIED AS FOLLOWS

a) **Nucleus Seed**: A 100% genetically and physically pure seed generated by breeder or State Agricultural Universities (SAUs) from basic seed stock. The producing breeder issues a pedigree certificate.

b) **Breeder Seed**: A progeny of a pedigree certificate holding nucleus seed multiplied in an extensive area as per the indent of Department of Agriculture and Cooperation(DOAC), Ministry of Agriculture, GOI under breeder's or SAUs' supervision, is termed as a breeder seed.

c) **Foundation Seed**: A 99.5% genetically pure breeder seed progeny generated by recognized seed producing agencies (public and private sector) under supervision of SCAs, such that its quality is maintained in accordance with the stipulated standards(field and seed).

d) **Registered Seed**: Progeny of foundation seed treated in such a way that its genetic identity and purity are maintained according to the minimum standards specified for particular crop.

e) **Certified Seed:** Progeny of foundation seed which is 99% genetically pure produced by authorized agencies. The certification conforms to section 8 of the Seeds Act, 1966 or certified by any Certification Agency established in any foreign country provided the Certification Agency has been recognized by the Central Government through notification in the Official Gazette.

f) **Labelled Seed**: Seeds notified in Section 5 sold in market need to be labelled under section 6(a) and 6(b) of the Seed Act, 1966.

CERTIFICATION PROCESS

Certification shall be conducted by the Certification Agency notified under section 8 of the Seeds Act, 1966 and Seed Rules 1968.

a) History: With the establishment of National Seed Corporation in 1963, the field evaluation of the seed crop and its certification was initiated. With the enactment of Seed Act in 1966 and formulations of Seed Rules in 1968, a legal status was provided for certification procedure and the required impetus for foundation of SCAs. In India, compulsory labelling and voluntary certification exists.

b) Objectives: The systematic increase of high yielding superior varieties and the provision of their continuous supply counts as the primary objective.

c) Eligibility requirements: Seeds of varieties notified under Section 5 of Seeds Act is eligible for certification. Further, field and seed standards should be met.

d) Procedure:

i. An administrative check on the propagating material to ensure true to type high quality seeds for sowing purpose is the first and foremost step performed by Seed Certification Programme.

ii. Field inspection of the growing crop is performed to ensure for varietal purity, appropriate isolation distance, rouging off of off-type plant material, prevent physical admixture and disease dissemination, etc.

iii. Sample inspection through laboratory tests for germination and other purity tests to assess the planting value of the seeds is conducted. This offers data concerning the genuinity of the lot and sample.

iv. **Control plot test**: The samples taken from the source and the final seed generated are cultivated alongside standard samples of the variety in concern. It is possible to verify whether the varietal purity and health of the generated seed are comparable to the results obtained from field examination.

e) Validity period of certificate: At the time of initial certification, the validity term should be nine months from the date of test. The validity period could be extended for another six months if the seed meets the prescribed standards for physical purity, germination, and insect damage for all seeds except vegetative propagating material, for which the entire batch must be re-examined for seed standards specified for the respective crop. A seed lot will be eligible for a validity period extension if it meets the stipulated conditions.

SEED STANDARDS

The 'Indian Minimum Seed Certification Standards' are the certification standards currently followed in India which are issued by the Central Seed Certification Board. As a general rule, these criteria have been kept at a level that requires fastidious attention from certified seed farmers while being feasible enough to be reached. These can be grouped into two categories:

a) **General Seed Certification Standards**: The goal of the general seed certification standard is to outline the general standards for producing genetically pure, high quality seed.

b) **Specific Crop Standards**: This includes field and seed standards.

THE FIELD STANDARDS COUNT FOR THE FOLLOWING

i. The minimum preceding crop requirement has been specified to minimize genetic contamination from the disease, volunteer plants.

ii. The minimum isolation requirement has been specified to minimize seed born disease contamination.

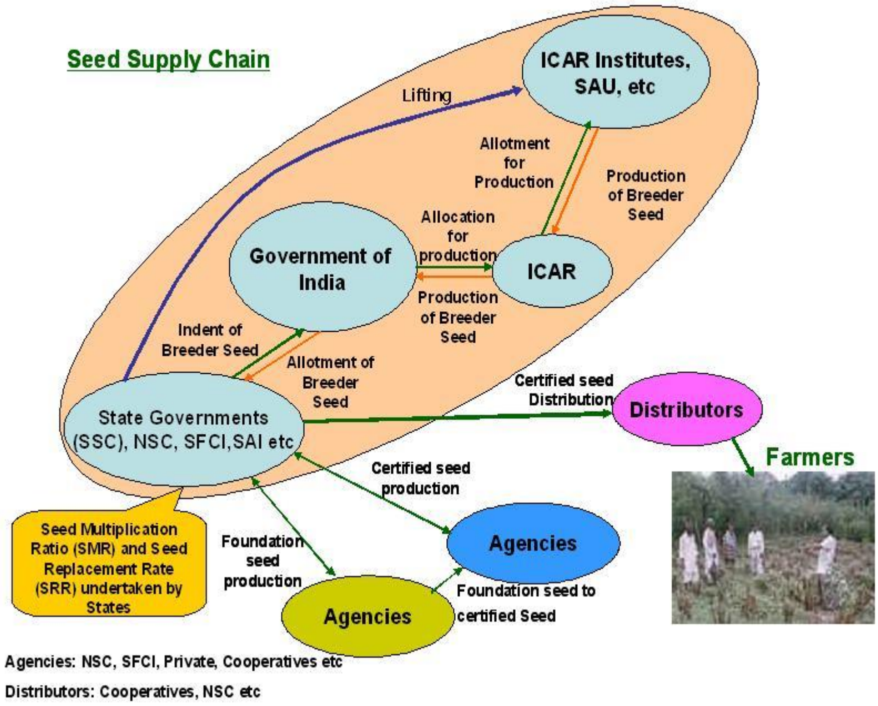
iii. The number of feed inspections at specified stage of crop has been described to ensure verification of genetic purity and other quality factors.

THE SEED STANDARDS PRESCRIBE FOR THE FOLLOWING

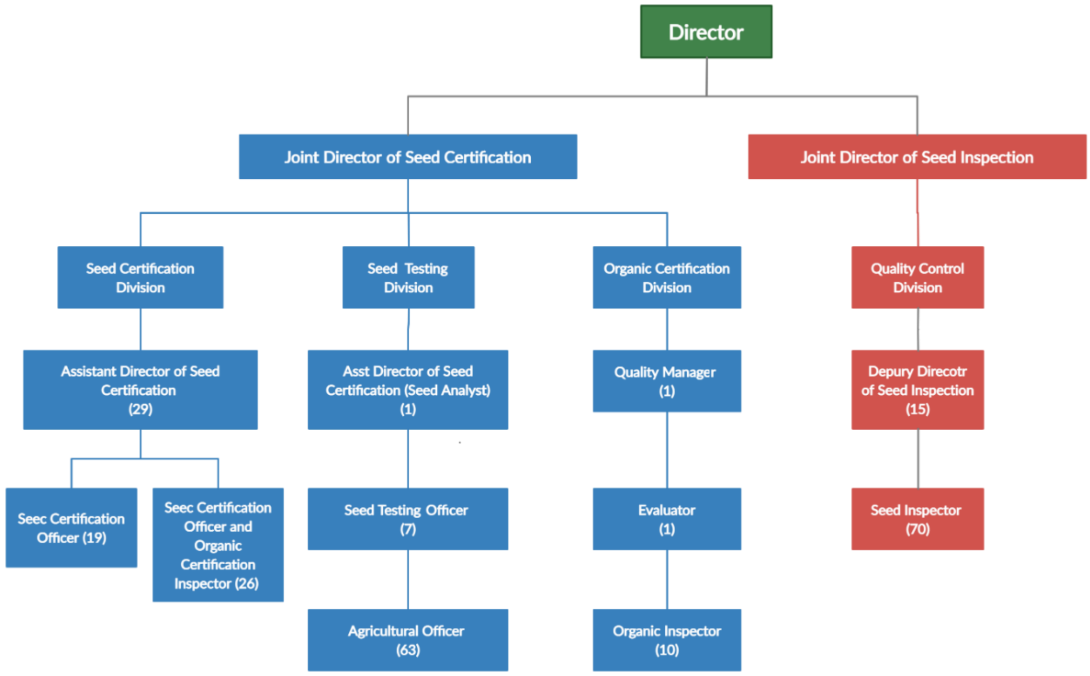
i. The minimum percentage of pure seeds and maximum permissible limit for inert matter and other crop seeds.

ii. The maximum permissible limits for objectionable weeds, seeds infected by seed borne diseases to ensure goods seed health.

iii. The maximum permissible limit of moisture content for the safe storage.



Seed Supply Chain



Seed

Certification process

1. **Certification Tags:**

Seed Class	Tag Colour	Tag Size
Breeder Seed	Golden Yellow	12x6cm
Foundation	White	15x7.5cm
Registered	Purple	15x7.5cm
Certified	Azure Blue	15x7.5cm

2. **Generation System of Seed Multiplication**: This is nothing but the creation of a certain class of seed from a specified class of seed up to the stage of certified seed. The selection of an appropriate seed multiplication model is critical to the future performance of a seed project, which is primarily dependent on

a. Genetic degradation rate,
b. Seed multiplication ratio, and
c. Total seed demand

Different seed multiplication models for each crop can be derived based on these factors, and the seed multiplication agency should decide how swiftly producers can be supplied with seed of newly released varieties after the nucleus seed stock has been handed over to the concerned agency, so that it can replace the old varieties.

a. Three - Generation model
Breeder seed - Foundation seed - Certified seed
b. Four - Generation model
Breeder seed - Foundation seed (I) Foundation seed (II) - Certified seed
c. Five - Generation model
Breeder seed - Foundation seed (I) - Foundation seed (II) -Certified seed (I) - Certified seed (II)

3. **Seed Certification Enforcement**: Seed inspectors will visit seed distribution organisations, check seed lots produced, take seed samples as per protocol, and have such samples tested to confirm that the seed meets the mandated certification criteria. Seed inspectors can issue orders to prohibit the selling of seeds, seize stocks, and commence prosecution if required. The organizational hierarchy is given in the following figure.

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Chapter 12

ECOLOGICAL FARMING OR ECO-FRIENDLY AGRICULTURE SYSTEM: A MODERN AND SUSTAINABLE ORGANIC FARMING SYSTEM

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ABSTRACT

Ecological farming both relies on and protects nature by taking advantage of natural goods and services, such as biodiversity, nutrient cycling, soil regeneration and natural enemies of pests, and integrating these natural goods into agro ecological systems that ensure food for all today and tomorrow. Ecological farming provides the ability of communities to feed themselves and ensures a future of healthy farming and healthy food to all people. Ecological farming protects soils from erosion and degradation, increases soil fertility, conserves water and natural habitats and reduces emission of greenhouse gases. Ecological farming is both a climate change mitigation and adaptation strategy. There are different types of Eco farming like permaculture, natural farming etc. there are many principles are involved in Eco farming like food sovereignty, biodiversity, sustainable soils, ecological pest control etc. so, Eco farming is a form of farming which utilizes the strengths of natural ecosystems to produce healthy and sustainable yield.

KEYWORDS: Ecological farming, biodiversity, healthy farming, sustainable yield.

INTRODUCTION

DEFINITION

"An ecological approach to farming that is designed to conserve biodiversity and natural resources" (Oxford Reference).

"Eco-farming is the act of farming without the use of toxic materials or harming the soil in any way. Biodiversity and nature are held to high standards in this way of farming. This method combines innovative methods and science-backed research" (Western packaging.com).

"Ecological farming (Eco-farming) is also known as ecologically appropriate agriculture, ecologically sound agriculture, biodynamic farming, organic farming, conservation agriculture and sustainable agriculture. Sustainable management and development means sustaining human wellbeing over time, i.e. satisfying the present needs without risking the possibility those future generations may not be able to satisfy their own needs. Therefore, sustainability implies providing future generations with as much, or more and better of the natural capital (land, water, air, genetic material, ecosystems, etc) per output as the current generation is enjoying" (Anon, 2008).

CONCEPT OF ECOFRIENDLY FARMING

Ecological farming both relies on and protects nature by taking advantage of nature's qualities and services, such as biodiversity, nutrient cycling, soil regeneration and natural enemies of pests, and integrating these natural qualities into agro ecological systems that ensure food for all today and tomorrow. Ecological farming ensures healthy farming and healthy food by protecting soil, water and climate, promotes biodiversity and do not pollute the environment with chemical inputs or genetic engineering.

Ecological farming basically rely on the fact that crops use resources from the ecosystem to fight pests, maintain or increase soil fertility, etc., and do not depend on the use of synthetic agro-chemicals such as fertilizers, pesticides, antibiotics or genetically modified organisms. The result of which is production of more natural, healthy and nutritious crops. Furthermore, it contributes to greater environmental sustainability while having a low environmental impact. Ecological farming is similar to organic farming, but it goes a step further by considering the entire ecosystem and acting only in accordance with the natural life cycle (Tirado, 2009).

NEED FOR ECOFRIENDLY FARMING

As 'Conventional Agricultural System' is destructive for the environment, unsustainable and have the following issues (Tirado, 2009):

1. It relies on expensive non-renewable and artificial resources like fossil fuels, synthetic chemicals, genetically engineered crops etc., that damage the basic natural resources needed for food production.
2. It pollutes nature with synthetic fertilizers and toxic chemicals that strip the soil of its fertility harm biodiversity and destroy nature's capacity to keep pests and disease under control.
3. It spreads genetically engineered varieties that threaten the biodiversity of our crop plants which have withstood local conditions for thousands of years and thus risk our ability to produce food under changing conditions. It threatens food security, giving a handful of chemical companies global control over food produced worldwide.
4. It endangers the future of our soils, our water, our climate and our forests, and it is based on the indiscriminate exploitation of natural resources and often on artificial monocultures.
5. It is a major source of global human-induced climate change gas emissions. Direct emissions from agriculture come mainly as methane from livestock and nitrous oxide from fertilized soils. Climate change will profoundly affect food production worldwide.
6. It is basically a model of agriculture promoted by agrochemical corporations whose main aim is to profit from sales of pesticides, synthetic fertilizers and genetically engineered seeds and not to feed the world. They are, in turn, supported and subsidized by the governments.

CHARACTERISTICS OF NATURAL ECOSYSTEMS

An ecological approach to agriculture involves designing the strengths of natural ecosystem into agroecosystems. The following strengths of natural ecosystems are utilized and imbibed in the development of ecofriendly farming (Magdoff, 2007):

1. **Efficiency**: Efficient energy flows are characteristic of natural systems. The sun's energy captured by green plants is then used by many organisms, as fungi and bacteria decompose organic residues and are then fed upon by other organisms, which are themselves fed upon by

others higher up the food web. Natural ecosystems also tend to be efficient in capturing and using rainfall and in mobilizing and cycling nutrients. This helps to keep the ecosystem from 'running down' through the excessive loss of nutrients and at the same time helps maintain the quality of the groundwater and surface waters. Precipitation tends to enter the porous soil, rather than runoff, providing water to plants as well as recharge to ground water, slowly releasing water to streams and rivers.

2. **Diversity**: A great biological diversity, both above ground and in the soil, characterizes many natural ecosystems in temperate and tropical regions. This provides checks and balances, nutrient availability to plants, checks on disease outbreaks, etc. For example, competition for resources and specific antagonisms (such as antibiotic production) from the multitude of soil organisms usually keep soil borne plant diseases from severely damaging a natural grassland or forest.
3. **Self-sufficiency**: A consequence of efficiency and diversity is that natural terrestrial ecosystems are self-sufficient—requiring only inputs of sunlight and rainfall.
4. **Self-regulation**: Because of the great diversity of organisms, outbreaks of diseases or insects that severely damage plants or animals are uncommon. In addition, plants have a number of defense mechanisms that help protect them from attack.
5. **Resiliency**: Disturbances occur in all ecosystems natural or not. The stronger ones are more resistant to disturbances and are able to bounce back quicker

OBJECTIVES OF ECOLOGICAL FARMING

Bringing to match the crop, soil and climate of a region the ecology and farming and gaining from the economy and efficiency of inputs are the objectives of eco-farming. According to Sankaram (1996), this technology may be grouped into four categories:

1. Those that reduce the environmental burden of greenhouse gases (CO_2 and CH_4), global warming, ozone depletion. All attention to promote renewable sources of energy (draught animal power), electrical energy from garbage disposal and biogas from organic wastes.
2. Those that reduce the demand on land, water and biodiversity without adverse effect on agricultural production and nutritive value of food. Nurse the soil back to health, change cropping patterns to maximize ecological productive efficiency, improve, water use efficiency-through conjunctive use of rain, tank, underground, well and river waters; reduce conveyance losses; phase out subsidies.
3. Those that continue to improve crop productivity, under shrinking land resources. (Genetic and agronomic) hybrid vigour, gene pyramiding; multiple cropping patterns, integrated nutrient management and integrated pest management.
4. Reduce hunger and poverty, adopt, cost effective farming to bring equity of food price and wage, encourage job promoted growth right in the village to arrest migration as ecological refugees.

PRACTICES INVOLVED IN ECOFREINDLY FARMING

Ecological farming is founded on a number of goals and principles, as well as good practices designed to reduce man's impact on the environment (prepp.in):

- Crop rotation is required for efficient use of farm resources.
- Due to their potentially harmful effects on the environment, fertilizers and synthetic chemical pesticides must be strictly limited in their use.

- The use of genetically modified organisms is prohibited.
- Encourage a diverse ecosystem to maintain soil fertility and pest control naturally (for example, by using animal manure and farm feed as fertilizer).
- Choosing plant species and animal breeds that are better suited to local conditions and potential pest and disease problems.
- Animals raised in the open and in shelters are fed organic feed.
- Using animal breeding practices that are specific to each breed.
- Farmers who practice ecological farming aren't just trying to keep the soil healthy, fertile, and natural. They also try to improve it by using appropriate nutrients, improving its structure, and managing water effectively.
- Many farmers currently maintain or plant hedges to prevent land erosion caused by wind.
- Simultaneously, these hedges and the various natural edges around the land contribute to the creation of ideal habitats for birds, insects, and other wildlife on farm land, thereby contributing to overall biodiversity.
- Ecological methods, such as interstitial crops and crop protection, as well as improving soil humus content, can help prevent nutrient infiltration in groundwater and surface waters and reduce the risk of soil erosion, thereby lowering the risk of water contamination.

PRINCIPLES OF ECO-FARMING

1. FOOD SOVEREIGNTY

- Food sovereignty is concerned with how and by whom food is produced. Food sovereignty places power in the hands of those who produce, distribute, and consume food.
- It guarantees farmers, communities, and individuals the right to define their own food systems.
- Food sovereignty recognizes women as the backbone of rural communities, as well as the historic role women have played in gathering seeds and sowing seeds as biodiversity guardians.
- Ecological farming practices are ideally suited for poor and smallholder farmers, as they require minimal or no external inputs, use locally and naturally available materials to produce high-quality products, and encourage a whole systemic approach to farming that is more diverse and resistant to stress (UNEP and UNCTAD, 2008).

2. REWARDING RURAL LIVELIHOODS

- Ecological farming contributes to rural development and poverty alleviation by providing safe, healthy, and economically viable livelihoods in rural communities.
- Ecological farming with practices based on biodiversity and without use of synthetic fertilizers or pesticides, can produce as much food per hectare as the conventional agriculture systems, and even increase yields, especially in developing countries.

CASE STUDIES

- A recent meta-analysis showed that globally, ecological farming can produce, on average, about 30 percent more food per hectare than conventional agriculture, and in developing countries organic farming can produce about 80 percent more food per hectare (Badgley et al 2007).
- An example of economic benefits of ecological farming is the success of the Non-Pesticide Management program in Andhra Pradesh (India) in reducing the costs of cultivation and increasing the net incomes of the farmers. The cost of cultivation was brought down significantly,

with savings on chemical pesticides ranging between 600 and 6000 Indian Rupees (US$ 15 - 150) per hectare without affecting the yields (Ramanjaneyulu *et al.,* 2008). This success has received the Indian Prime Minister's attention and was selected under a National Agriculture Development Project to scale up non-pesticide into organic farming in 5000 villages over the next five years covering 10 million hectares.

- Ecological farming represents a significant net saving for citizens. For example in the UK, if the whole farming system shifted to organic farming, environmental costs savings would be of about 1 billion £ per year (1.5 billion US$) (Pretty *et al.,* 2005).

SMARTER FOOD PRODUCTION AND YIELDS

- To increase global food availability and improve livelihoods in poorer regions, we must reduce unsustainable use of what we currently grow, as well as reduce food waste, meat consumption, and land use for bioenergy.
- Higher yields must be achieved through ecological means where they are required.

BIODIVERSITY

- Ecological farming is primarily concerned with the diversity of nature from the seed to the plate and throughout the agricultural system.
- It is about improving diets and health by improving the flavour, nutrition, and culture of the food we eat.
- Promoting crop diversity rather than monocultures such as corn and soy is critical to environmental protection.
- Diversity farming is the single most important modern technology to achieve food security in a changing climate. Scientists have shown that diversity provides a natural insurance policy against major ecosystem changes, be it in the wild or in agriculture (Chapin *et al.,* 2000, Diaz *et al.,* 2006).

CASE STUDIES

- In the United States, agronomists compared corn yields over three years between fields planted as monocultures and those with various levels of intercropping in Michigan. They found the yields in fields with the highest diversity (three crops, plus three cover crops) were over 100 percent higher than those cropped in continuous monocultures. Crop diversity improved soil fertility, reducing the need to use chemical inputs while maintaining high yields (Smith *et al.,* 2008)
- In rainfed wheat fields in Italy, high genetic diversity within fields reduces risk of crop failure during dry conditions. In a model scenario where rainfall declines by 20 percent, the wheat yield would fall sharply. But when diversity is increased, this decline is reversed and yields are larger than average (Di Falco and Chavas, 2006, 2008).

SUSTAINABLE SOIL

- Soil fertility can be improved by using eco-farming methods and avoiding the use of chemical fertilizers and inputs.
- Soils are protected from erosion, pollution, and acidification by ecological farming.
- We can improve water retention and prevent land degradation by increasing soil organic matter where necessary.

- Growing legumes and/or adding compost, animal dung or green manures are some smart ways to increase organic matter and fertility of the soil. Natural nutrient cycling and nitrogen fixation can provide fertility without synthetic fertilizers, and at the same time cut farmers' expenses on artificial inputs and provide a healthier soil, rich in organic matter, better able to hold water and less prone to erosion.
- The use of organic fertilizers, generally cheap and locally available, makes ecological farming more secure and less vulnerable to external inputs' accessibility and price fluctuation.
- Sequestration of carbon in farming soils can also significantly contribute to climate change mitigation.

CASE STUDIES

- In a 21-year-long study on European farms, soils that were fertilized organically showed better soil stability, enhanced soil fertility and higher biodiversity, including activity of microbes and earthworms, than soils fertilized synthetically (Mäder *et al.*, 2002).
- In apple orchards in the US, fertilization with manure (compared to fertilization with chemical fertilizers) increases the amount of carbon stored in the soil, increases the diversity and activity of soil microbes, and decreases the losses of nitrates to water bodies while keeping nitrous oxide losses to atmosphere similar (Kramer *et al.*, 2006).

ECOLOGICAL PEST CONTROL

- Ecological farming allows farmers to control pests without the use of costly chemical pesticides, which can harm our soil, water, and ecosystems, as well as farmers' and consumers' health.
- Toxic chemical pesticides endanger human health and the health of the environment.
- Unfortunately, industrial farming relies on large amounts of herbicides, fungicides, and insecticides to survive.
- Our current food system has entangled farmers in an expensive relationship with the corporations that sell all of these chemicals.
- Ecological farming can achieve pest protection in crop fields without relying on pesticides, by making croplands more resilient to pests. Farmers can find long-term solutions to pest problems by designing diverse crop fields and using low-input technologies locally available.
- Ecological pest protection is based on enhancing the "immunity" of the agroecosystems and promoting healthy soils and healthy plants (Altieri and Nicholls, 2005).
- By designing agroecosystems that on the one side work against the pests' performance and on the other are less vulnerable to pest invasion, farmers can substantially reduce pest numbers (Gardiner *et al.*, 2009).

CASE STUDIES

- In Africa, scientists at the International Centre of Insect Physiology and Ecology (ICIPE) developed the push-pull system to fight maize stem borers without use of chemicals. Grasses planted on the borders of maize fields (Napier grass and Sudan grass) attract insect pests away from maize – the pull, and two plants intercropped with maize (molasses grass and the legume silver leaf) repel the insect pests from the crop – the push (Hassanali *et al.*, 2008). The push-pull system has been tested by over 4000 farmers in Kenya and about 500 farmers in Uganda and Tanzania, with impressive positive outcomes. Farms using push-pull systems showed between

40 and 90 percent less attack of stem borers and, on average, 50 percent higher yields of maize than monocrop farms.

- In the state of Andhra Pradesh in India, a pesticide-free farming revolution has taken place from the success from a few villages has been scaled up into more than 1.5 million hectares, benefiting more than 350 thousand farmers from 1800 villages in eighteen districts of the state; 50 villages have become pesticide-free and 7 villages have gone completely organic (Ramanjaneyulu *et al.*, 2008).
- Another example of this success is the performance of nonpesticide management in genetically engineered Bt cotton2 and non-Bt cotton, studied by the Central Research Institute of Dry land Agriculture (CRIDA). This study showed that non-pesticide management in non-Bt cotton is more economical compared to Bt cotton with or without pesticide use (Prasad and Rao, 2006).

FOOD RESILIENCE

- Ecological farming fosters resilience, which strengthens agriculture and effectively adapts our food system to changing climatic and economic realities.
- Diverse and resilient agriculture, rather than monoculture crops, is the best way to protect communities from climate and food price shocks.

TYPES OF ECOLOGICAL FARMING (KRISHIJAGRAN.COM)

BIODYNAMIC AGRICULTURE

- Rudolf Steiner developed biodynamic agriculture in 1924.
- The farm is treated as a living organism in this system, which takes a holistic approach.
- The goal of biodynamic agriculture is to avoid using any inputs on the farm.
- Other methods of improving soil fertility include the use of cover crops and animal manure.
- Farmers frequently use homoeopathic preparations to treat the soil, plants, and compost.
- They also consider natural rhythms when performing farming tasks such as seeding.

PERMACULTURE

- It was developed in Australia in the 1970s by David Holmgren and Bill Mollison.
- Farmers use permaculture to create various agricultural areas where they develop productive ecosystems with the same diversity, resilience, and stability as natural ecosystems.
- Permaculture, in practice, mimics plant growth in natural ecosystems while requiring little maintenance.

NATURAL FARMING/FUKUOKA FARMING

- It is based on Masanobu Fukuoka's principles.
- Farmers work with natural cycles and processes rather than using conventional farming techniques.
- Fukuoka farming does not use fertilizers or pesticides, and it is anti-till and weeding.
- The use of clay seed balls, an ancient technique used to mix crop seeds with humus or compost and roll them into clay balls, is one feature of this type of farming.

METHODS AND TECHNIQUES OF ECO-FARMING

When practising ecological farming, a variety of methods and techniques are used, each with their own set of benefits and implementations that lead to more sustainable agriculture.

- **Polyculture or Crop Diversity**: It is the practice of growing a variety of crop species on the same farm land.
  - Each plant species absorbs different nutrients from the soil and excretes different substances.
  - This method promotes soil fertility without the use of chemical fertilizers.
  - Furthermore, a variety of crops attracts a variety of insects, wild plants, and microorganisms, thereby increasing biodiversity.
  - This method is used to reduce the risks associated with monoculture crops, which can be vulnerable to climate change.
  - This type of biodiversity makes crops more resilient, increasing food security and field productivity over time.
- **Biodigestors**: This converts organic waste into a combustible gas that can be used as a fuel source, fertilizer for crops and fish ponds, and a method for removing wastes rich in organic matter.
  - Because biodigestors can be used as fertilizer, the amount of industrial fertilizer required to sustain farm yields is reduced.
- **Aquaculture integration**: This combines fish farming with agricultural farming by diverting waste from animals and crops to fish farms to be used up rather than being leeched into the environment. Fish pond mud can also be used to fertilize crops.
- **Organic fertilizers (Animal and Green manure):** They can also be used in an ecological farm. This improves and maintains soil fertility, which leads to lower costs and higher yields, reduces the use of non-renewable resources in industrial fertilizers (Nitrogen and Phosphorus), and reduces the environmental pressures posed by intensive agricultural systems.
- **Precision Agriculture**: This focuses on efficient pest removal using non-chemical techniques and minimizes the amount of tilling required to sustain the farm.
- **Small Sized Farms**: Smaller farms are better suited to ecological farming because they are easier to maintain without the use of chemicals or farm machinery.
  - Crop rotation is also more effective when done on smaller farms. This method can also help to increase biodiversity.
- **Soil Fertility**: Because the primary goal of ecological farming is to use only natural fertilizers, soil fertility is the most important factor.
  - Soil fertility is essential for sustainability because it allows the farm to continue serving its function as an organic piece of land for an extended period of time, as opposed to synthetic substances used in traditional farming, which reduce the life span of the soil.

ADVANTAGES OF ECO-FARMING

- Eco-farming entails the introduction of symbiotic species to support the farm's ecological sustainability. Benefits include reduced ecological debt and the elimination of dead zones.
- Ecological foods do not contain synthetic additives, which can lead to health issues such as heart failure, osteoporosis, migraines, allergies, hyperactivity, and Parkinson's disease, among others.
- Furthermore, the use of synthetic substances in food culture, production, or preservation is not required. There is no need to look for out-of-season products to meet the nutritional needs of the body.

- Ecological products are healthier because they are free of pesticides, insecticides, antibiotics, synthetic fertilizers, additives, and preservatives.
- They contain no artificial substances; the foods from ecological farming are properly assimilated by the organism without interfering with metabolic functions.
- Ecological farming makes economic sense. This modern farming system increases crop yields. Ecological farming can produce 30% more food per hectare globally.
- Another important aspect of ecological farming is organic pest control. Ecological farmers use non-polluting, long-term pest protection instead of chemical pesticides in this system. Beneficial insects can be introduced into the field as one method.
- One of the advantages of ecological products is that they respect the environment. Farmers who grow ecological crops contribute to environmental conservation by avoiding contamination of land, water, and air.
- Ecological farming is the most environmentally friendly because it produces less aerosol pollution, less carbon dioxide, prevents the greenhouse effect, does not generate polluting waste, and aids in energy savings by utilizing as many renewable resources as possible in crop cultivation and product production.
- Ecological farming is a pioneering, practical development that aims to create globally sustainable land management systems and promotes reconsideration of the importance of biodiversity in food production and farming end products.

CHALLENGES FACED BY ECO-FARMING

- The challenge for ecological farming science is to develop a mainstream productive food system that is both sustainable and regenerative.
- To enter the field of ecological farming, location relative to the consumer can help reduce the food miles factor, which can help reduce damage to the biosphere caused by combustion engine emissions involved in current food transportation.
- The design of an ecological farm is initially constrained by the same constraints as conventional farming: local climate, the physical properties of the soil, a budget for beneficial soil supplements, manpower etc.
- Possible alternate uses for crop residues are also a potential impediment in the implementation of an ecological agriculture that calls for returning as much biomass to the soil as possible. For example, dry cow dung in India is used as fuel and 60% of crop residues in China and 90% in Bangladesh are burned for fuel.

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Chapter 13

BIOREMEDIATION OF HEAVY METALS- A MICROBIAL APPROACH

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ABSTRACT

Rapid industrialization and anthropogenic conditioning similar to the unmanaged use of agrochemicals, reactionary energy burning and dumping of sewage sludge have caused soils and waterways to be contaminated largely with heavy metals. Exploiting microorganisms for the removal of heavy metals is a promising approach to combat these adverse consequences. Microbial remediation is very pivotal to help the filtering of heavy metal or mobilization into the ecosystem and also to make heavy metal extraction simpler. Technological breakthroughs in microbes-based heavy metals have pushed bioremediation as a promising alternative to standard approaches. This chapter summarizes various processes of heavy metal bioremediation, such as Biosorption, bioaccumulation, bioleaching, bio mineralization, and biotransformation.

KEYWORDS: Heavy metals, bioremediation, Biosorption, bioaccumulation, bioleaching, bio mineralization, biotransformation.

INTRODUCTION

Heavy metal pollution is drastically increasing due to population blast, anthropogenic activities, and modern industrialization. Today, one of the most destructive effects facing the world is the contamination with heavy metals, which reaches the air, soil, and water[1, 26]. Contamination of water and air by toxic metals is an environmental concern and hundreds of millions of people are being affected around the world. In humans, heavy metal toxicity can cause cancer, cardiovascular and neurological diseases, liver damage as well as central nervous system and sensory disturbances. In plants, heavy metals can cause chlorosis, reduced seed germination, and reduced growth because of decreased rate of photosynthesis, mineral nutrition, and reduced enzyme activities[7, 8].

Several methods have been accomplished to remediate heavy metals pollution, among them physico-chemical (conventional) methods such as ion exchange, redox, electrochemical techniques, membrane filtration, and precipitation are used [9, 10]. Metal precipitation has been proven to be cost-effective and easy to use. However, it may cause secondary environmental issues[11]. Other mentioned techniques proved to be environmentally friendly, but expensive and relatively inefficient in removing heavy metals, and also organic contaminants[12, 13]. To solve these problems, bioremediation is an important, attractive, cost-effective, and environment-friendly method as this technique utilizes microorganisms that are naturally available in contaminated sites and can readily assist in the removal of heavy metals[14].

Microorganisms especially soil microbes can tolerate high levels of heavy metals; some microorganisms need certain types of metals as a micronutrient to perform their metabolic activities[15]. Microorganisms are ubiquitous; they are minute and multiply rapidly, and increase in huge numbers when inoculated to contaminated sites[16]. When they are continuously exposed to pollutants, they become tolerant and exhibit exceptional levels of capability to transform pollutants as their source of energy and raw material. They can also genetically adapt to degrade the contaminants. These attributes can be exploited to make microorganisms an ideal candidate for a low-cost and more environment- friendly biological process[17].

DEFINITION OF HEAVY METALS

These can be defined as the elements that have a density higher than 5 g/cm^3, also the metals or metalloids which have an atomic mass greater than 4000 kg m^{-3} or 5 times larger than water are considered heavy metals[18]. A lot of elements fall into this class however, only a few metals like arsenic (As), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), tin (Sn), vanadium (V) and zinc (Zn) commonly existed in the contaminated air, water, and soil. These metals could be found in many forms; insoluble such as carbonate, oxides, silicate, and sulfides, or soluble such as salt forms[19]. The heavy metals when persisted in their ionic state (e.g., Cd^{+2}, Pb^{+2}, Hg^{+2}, As^{+3}) represent the most toxic form as they combined with bio-molecules and becomes harder to be dissociated[20]. Recently, researchers paid great attention to studying the diffusion phenomenon and mobility through soil layers[21].

PRINCIPLES OF THE BIOREMEDIATION PROCESS

Bioremediation can be defined as the use of biological diversity, directly or indirectly, to convert toxic pollutants into a harmless form[22], so bioremediation is a holistic approach that includes plants, fungi, bacteria, actinomycetes, and algae all of them could be used as a biological agent to detoxify heavy metals. Two different strategies are utilized to remediate toxic pollutants;

- In-situ, where the process of decontamination occurred at the contaminated place itself by bringing the biological agent to the site of contamination or promoting the indigenous organisms to deal with contaminants by facilitating the suitable condition for their propagation.
- Ex-situ, by which the contaminated place is transferred away to another site to be processed[22-26].

There are many mechanisms by which the organism can manipulate the detoxification process; however, the utilization of the toxic metal by the microorganism as a source of nutrition is the main concept[27].

MECHANISM OF BIOREMEDIATION

Bioremediation is a branch of biotechnology that employs the use of living organisms, like microbes and bacteria, in the removal of contaminants, pollutants, and toxins from soil, water, and other environments. The mechanisms adopted by the microorganisms to detoxify the heavy metals are:

BIOSORPTION

This is an interactive process in which metal ions bind non-specifically to polysaccharides and proteins present on the cell surface. It is a feature in which both living cells and dead microbial biomass provide binding sites[28]. Bacteria exhibit metal adsorption because of the peptidoglycan layer present in them. Gram-positive bacteria exhibit multiple layers of peptidoglycan which consist of teichoic acid (unique to Gram-positive bacteria), amino acids (alanine and glutamate), and meso-diaminopimelic acid, while in Gram-negative bacteria, there is only one layer of peptidoglycan[29], that consists of enzymes, glycoproteins, lipopolysaccharides and phospholipids. These molecules act as ligands and offer active sites for metal-binding[30, 31]. Teichoic acid and other acidic groups present in the cell wall are sources of carboxyl groups that play a crucial role in metal uptake [32]. Therefore, Gram-positive bacteria can adsorb more metal ions than Gram-negative bacteria. The cell wall also has complex carbohydrates, lipids, nucleic acids, and proteins which constitute extra polymer substances (EPS). EPS shows great metal-binding ability towards complex heavy metals and prevents their entry into the microbial intracellular environment. Thus, they protect microbes against heavy metal toxicity[33]

In scientific studies, fungi have been extensively employed to carry out heavy metal adsorption. They have exhibited efficient metal-uptake ability and established themselves as good biosorbents[34]. This is because the fungal surface is composed of lipids such as chitins, glucans and mannans, proteins, and polysaccharides. Mannan contains negatively charged groups such as amino groups, carboxyl, phosphates, and sulfates. Various studies have been undertaken to check the fungal metal binding ability. Besides, photosynthetic organisms like algae have been reported to have good heavy metal absorption capabilities. Algal mass surface accumulates heavy-metal ions because it contains cell polymeric substances (peptides and polysaccharides), polysaccharides such as alginate and cellulose, organic proteins and lipids, and functional groups like carboxyl, amino, hydroxyl, phosphate, imidazole, thiol, sulphonate, etc. in the algal cell wall [35].

BIOACCUMULATION

Bioaccumulation involves heavy metal uptake by living biomass (metabolism-dependent/active uptake) and is characterized by the uptake of contaminants by living biomass/cells. Employing living biomass for remediation may not be a viable option owing to highly toxic metals which can accumulate in cells and interrupt metabolic activities resulting in cell death[37].

This is a metabolically active process that depends on the import-storage system. The system transports heavy metal ions across the lipid bilayer into the cytoplasm or intracellular spaces using transporter proteins. The metal ions are sequestered by metal-binding entities such as proteins and peptide ligands[3], and the heavy metals which are sequestered by these entities can occur in particulate forms, insoluble forms, and their by-products [38]. In the bacterial membrane, heavy metal bioaccumulation mechanisms can be attributed to endocytosis, ion channels, carrier-mediated transport, complex permeation, and lipid permeation [39-41].

BIOLEACHING

In bioleaching, microbes like bacteria and fungi which are present in nature, solubilize metal sulfides and oxides from ores deposits and secondary wastes [42, 43]. The solubilized metals are then purified using suitable technologies which include adsorption, ion exchange, membrane separation, and selective precipitation [43]. It is an economical and environment-friendly process, as it uses less energy and does not emit harmful gases [44]. It has been used for centuries to leach metals from low-grade ores and currently supports a lucrative global market in the extraction of metals such as copper, cobalt, gold, nickel, uranium, zinc, etc.[45].

Bioleaching can be achieved by contact and non-contact mechanisms. In the contact mechanism, a non-random physical contact occurs between the mineral sulfide and bacterial cell [46]. Oxidation to sulfate occurs through several reactions catalyzed by enzymes and causes electron transfer from the mineral surface [47]. In a non-contact mechanism, there is no physical contact between the bacterial cell and the mineral surface. Bacteria generate lixiviant (ferric iron) which chemically oxidizes the sulphide mineral. This reaction occurs only in an acidic environment below pH - 5.0 [48]. A wide range of microorganisms are involved in bioleaching and acidophiles occupy an important place.

BIOMINERALIZATION

The bio mineralization of metal ions is a natural process of mineral formation. It occurs through a natural synthesis of minerals such as carbonates, oxides, silicates, sulfates, and phosphates, and involves different mechanisms attributed to the activities of living organisms [49]. The presence of highly variable and highly reactive interfaces such as cell wall and additional organic layers (EPS and S-layer) with different hydration, composition, and structure are crucial factors for mineral formation. Besides, there are organic ligands such as amine, carboxyl, hydroxyl, phosphoryl, and sulfur which deprotonate and impart a net negative charge on the microbial surface with an increase in pH [50]. Potential toxic metals having positive charge precipitate non-uniformly into more stable and compact mineral products [51]. Metal immobilization can be achieved by phosphate precipitation, carbonate precipitation, oxalate precipitation, etc.[52–55]. Recently, numerous studies have demonstrated that remediation of toxic heavy metal ions such as copper, cadmium, lead, manganese, nickel, uranium, and zinc can be achieved by biomineralization [55–57].

BIOTRANSFORMATION

This is the process by which the structure of a chemical compound is modified, leading to the synthesis of a molecule with relatively more polarity [58, 59]. In other words, by this metal–microbe interaction process metal and organic compounds are modified from a toxic form to a relatively less toxic form. This mechanism has evolved in microbes to help them acclimatize to changes in the environment. Microbial cells have a high surface–volume ratio, high growth rate, and high rate of metabolic activity, and maintenance of sterile condition is easy. Therefore, they are ideal for biotransformation. This process can be achieved through condensation, hydrolysis, formation of new carbon bonds, isomerization, introduction of functional groups, oxidation, reduction, and methylation. These reactions may lead to the volatization of metals and reduce their toxicity [60]. Microbial transformation is being used widely for the transformation of various pollutants, including hydrocarbons, pharmaceutical substances, and metals [61].

CONCLUSION

In summary, the use of microorganisms for heavy metal bioremediation is environmentally friendly, efficient, and economical. Microbes are ubiquitous and show fast growth. In heavy metal-contaminated sites, they become accustomed to heavy metal ions. They interact with the metal ions and therefore develop strategies of tolerance and resistance against them.

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Chapter
14

SUSTAINABLE AGRICULTURE: NEED OF THE HOUR

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ABSTRACT

The unearthing of 'Green revolution' came up with the high usage and over dependence on synthetic agrochemicals which later started causing environmental degradation. To tackle this serious issue of environmental management, sustainable agriculture became as a savior. Sustainable agriculture is a way of producing agricultural crops in an eco-friendly manner by ensuring profit. It works on three ecological, economic, and social levels and hence has become the need of the hour. In the present chapter, a brief overview of sustainable agro-practices and eco-friendly farming methods has been taken to create awareness and popularize the concept further ahead.

KEYWORDS: Sustainable agri-practices, eco-friendly farming, crop rotation, soil fertility, biodynamic farming, agroforestry, permaculture, carbon farming.

INTRODUCTION

The advent of 'Green revolution' could address the problem of hunger for the ever-increasing population of the world but it came with a great price tag and caused drastic damaging impacts on environment by tremendously increasing the dependence on synthetic agrochemicals. Therefore, within few decades, the world realized the side effects of green revolution and thus, the need of sustainable farming had arisen.

Sustainable agriculture refers to the unique agricultural activity that involves an eco-friendly farming which reduces the usage of non-renewable energy by decreasing agrochemical needs. Sustainable agriculture possesses three main characteristics viz., economic viability, social backing, and ecological soundness. It supports the achievement of global objectives, like the Sustainable Development Goals and Zero Hunger. Statistically, it is a proven fact that in comparison with conventional farming, the sustainable agriculture uses up to 56 percent less energy/unit of crops production and emits around 64 percent less greenhouse gases/hectare by supporting biodiversity to the greater extent (Sustainable Development Goals, 2021).

OBJECTIVES OF SUSTAINABLE AGRICULTURE

- To provide food and fibre security
- To boost food chain productivity
- To ensure and encourage soil fertility and biodiversity
- To improve agroecology by preventing pollution
- To foster resilience of Forst ecosystems and plant communities

- To encourage the optimum usage of renewable resources
- To support rural development and growth
- To enhance the standard of living of farmer community
- To support governmental initiatives and regulations
- To educate people and create environmental consciousness amongst them

PRINCIPLE OF SUSTAINABLE AGRICULTURE

It works on the principle of maximizing the crop production with desirable outcomes with the optimum utilization and management of available resources without causing environmental degradation. There are three pillars of agricultural sustainability, which are as follows:

- **Environmental Sustainability:** This pillar is responsible to take care of the environment. It suggests optimum utilization and recycling of agricultural resources, development, and use of integrated approaches, minimizing the agro-waste and reducing the negative impacts on the natural and physical environment of the planet (Kogut, 2022).
- **Economic Sustainability:** This pillar looks after the sustainable profitability of agro-businesses. It helps to enhance and protect the financial viability of crops and fields. It supports the longevity of agro-business and enhances their ability of re-investing and regenerating the profit. It thereby helps to enhance standard of living of the farmers (Kogut, 2022).
- **Social Sustainability:** This pillar is people-centric and takes care of the basic needs of the population. It ensures food security for all by guaranteeing food access to humans. It aims for the improvement in human welfare and their stabilization at the social level (Kogut, 2022).

SUSTAINABLE FARMING METHODS

Following are the eco-friendly farming techniques those promote sustainable agriculture:

- **Ecological Farming:** It is also known as biological or organic farming as it mainly depends on the use of organic products like biofertilizers to produce healthy, tasty nutritious food crops by enhancing the soil health and its water and nutrient holding capacity. It is a sustainable practice as it eliminates the use of synthetic products like chemical weedicides, pesticides, insecticides, growth promoters, etc. and thereby also mitigates the problem of soil, water and air pollution to a great extent. Besides, the organic products used are free from the glyphosate-like agents which otherwise impact bees which play an essential role in pollination. It enhances the defense mechanism of the plants and makes them strong, healthy, and naturally pest and disease resistant. It also helps in effective biodegradable waste management by reusing and recycling it as resources (Mishra, 2013).
- **Permaculture:** It refers to the cultivation of agro-farms by mimicking the natural ecosystem. It is farming by worshiping nature and getting the crop yield in the form of nature's blessings. It is a sustainable agriculture practice, in true sense, as it contributes to enhance earth's natural properties. It includes activities like harvesting and recycling rain water, growing crops without ploughing, using renewable energy sources, using bio-waste as resource, using organic fertilizers, constructing bunds, reducing the usage of agrochemicals and machines, usage of solar panels, etc. It tries to lessen carbon footprints and advocates for biodiversity conservation (Gupta, Pradhan, Jain, & Nayha, 2021).

- **Biodynamic Farming:** It is eco-friendly, cost-effective, sustainable farming practice. In conventional agriculture, plant and animal production are often kept separate. However, research suggests that integration of agricultural and animal production might increase farm efficiency and profitability. Therefore, in biodynamic farming, the rearing and growing of livestock and cultivation of crop plants is carried out together on the same land. It focuses on generation the soil fertility required for food production onsite through the implementation of practices like composting, application of animal manure from farmed animals, cover cropping, crop rotation, and so on (Eco-friendly Farms, 2022).
- **Agroforestry:** Agroforestry is defined as 'a sustainable use of land that increases the total yield by combing food crops together with forest crops and live-stock ranching, by using the best management practices that take care of the social, cultural, economic and ecological background of the local people and the region'. Agroforestry combines the principles and technologies of agriculture and forestry to create diverse, productive, eco-friendly, and sustainable system. Agroforestry enhances the soil fertility, stability, and soil microclimate by planting well managed tall trees along with agro crops and pasture lands. It improves the environment for protecting agriculture from adverse climatic factors. It increases the supply of wood fuel for domestic use, small timber for rural housing, fodder for livestock, and minor forest produce for local industries. It adds to the natural beauty of the landscape and creates recreational forests for the benefit of rural population. It carries out the rehabilitation of the land. It provides jobs for unskilled workers. It raises the standard of living and quality of life of the rural people (Sustainable Agricultural Methods and Farming Practices, 2015).
- **Urban Agriculture:** It is also known as city farming. It refers to the agricultural production of food crop and its further post-harvest management in urban and peri-urban areas. Urban agriculture promotes sustainable food production to fulfill the needs of urban people at a local level. Urban agriculture helps to lessen the impact of the carbon footprints by creating clean, green spaces. It thereby helps in effective environment, ecosystem, and climate management. It also helps for the economic and social development of the community in a sustainable manner (Sustainable Agricultural Methods and Farming Practices, 2015).
- **Hydroponics:** It is the method of plant cultivation which is suitable for both outdoor and indoor levels. It is a sustainable method which skips the use of soil and replaces it with nutrient rich water. It is so efficient system that it reduces the pressure on underground water tables by 80% to 90%. Besides, it recycles water for multiple times during cultivation. Since nutrient water is used, such cultivation is less susceptible to insect and pest attack. It manages fast growth and high yield of the plants all the year around. It involves plant cultivation in small space with hassel-free, easy harvesting. It has been proven successful for the cultivation of leafy vegetables, micro greens, basil, peppers, tomatoes, and strawberries (Howell, 2022).
- **Aquaponics:** It is the modified version of hydroponics which involves combination of aquaculture and hydroponics. It involves fish farming and plant cultivation together using nutrient rich water as medium. This is also a sustainable system as it works on the principle of mutualism. In this system, the plants help to purify water; make it oxygen rich and thereby fulfills fish's oxygen requirement. In return, the fish manure acts as a fertilizer for the plants

under hydroponic cultivation. Over the conventional agriculture, aquaponics reduces the water usage by ten times by recycling the water efficiently. It is the as it works under closed, regulated conditions and thereby becomes climate adaptive, energy saving system. Thus, it is the highly profitable, chemical free, high productive system (What is sustainable agriculture?, 2022).

- **Aeroponics:** It is also the modified version of hydroponics which involves the cultivation of crop plants in an air or mist environment, without using soil or other aggregate medium. In this, nutrient water solution is used in mist form to nurture the plants under cultivation (Howell, 2022).
- **Vertical Farming:** It is the practice of cultivating food crops vertically in stacked trays or towers rather than growing horizontally on flat ground surfaces. It can also be incorporated inside a greenhouse with controlled-environment agriculture (CEA) to optimize the crop growth. Vertical farming makes optimum use of light, water, soil and space and also increases production throughout the year rather than only in a specific season. Therefore, it becomes a sustainable agricultural option (Sustainability and Food Security, 2023).
- **Carbon farming:** Carbon sequestration is the process of capturing carbon dioxide and storing it as carbon. A carbon sink absorbs more carbon dioxide than it releases. Carbon farming involves increasing the amount of carbon sequestration and decreasing the amount of carbon dioxide release into the atmosphere. When the farm is able to store more carbon than they lose, the sequestered carbon can be sold as 'Carbon Credits'. Sustainable agriculture can act as a carbon sink by practicing tillage management, crop rotation, biofertilizers usage, biodiversity conservation, etc. Farmers using eco-friendly methods of cultivation that regenerate and optimize the resources soil, air, water, nutrients, etc., have a greater opportunity to sell carbon credits (Eco-friendly Farms, 2022).

SUSTAINABLE AGRO-PRACTICES

Following are the best practices which enhance the efficiency of the above-mentioned agro-techniques and take the agriculture to the greater level of sustainability:

- **Use of renewable energy resources:** Sustainable agriculture employs renewable sources of energy such as solar panel and power, hydropower, wind power, hydroelectric power, geothermal heat pumps for performing various agricultural operations. These alternative energy sources offer sustainability and eco-friendly farming options to growers (Best Eco-friendly Farming Practices to ensure sustainability, 2021).
- **Polyculturing:** It is also known as intercropping. It is an ancient practice which involves careful selection and cultivation of a few crops together, in the same farm simultaneously. It is a truly sustainable practice as it helps to increases biodiversity. It enhances soil health by eliminating the use of synthetic fertilizers and pesticides. It is better practice over monoculturing as polycultured plants show better hybrid vigour, pest-disease resistance, lower fertilizer requirements, and greater stability (Sowinski, K. A. and Sowinska, J., 2019).
- **Crop rotation:** It refers to the sustainable soil and farm management practice of cultivating different crops in succession in the same farm. Like intercropping, crop rotation also gives similar benefits. It helps farmers to reduce the risk of plant diseases. As a result, fewer pesticides and chemical fertilizers are required. (Eco-friendly Farms, 2022).

- **Planting cover crops and perennials:** Cover crops are the crops which are used to cover the soil by planting off-season after the harvest of the target crop. They are planted only for soil covering and never for harvesting. They are used primarily to slow down soil erosion, enhance soil microclimate and soil health, enhance water availability, manage weeds, control pests and diseases, and increase biodiversity. Cover crops increase nitrogen availability to the target crop by enhancing soil microclimate and soil microflora activity. This results in higher crop yield by increased nitrogen uptake in the target crop (What is sustainable agriculture?, 2022).
- **Use of biofertilizers:** Sustainability practitioners minimize the use of chemical fertilizers and pesticides. They use compost, organic manures or nitrogen fixing plants like legumes with root nodules containing nitrogen fixing bacteria. Similarly, the aggressive pesticides are replaced by the application of bio-controlling methods like use of natural enemies or predators for the pest and disease control. (Kogut, 2022).
- **Tillage management:** Tillage refers to ploughing the land through mechanized digging, stirring, and turning over. It not only agitates the soil and destroys its good properties but also leads to excessive green-house gas (GHG). emissions. Farmers can cut GHG emissions and fossil fuel consumption by controlling tillage practices and thereby contribute towards sustainable eco-friendly agriculture (Best Eco-friendly Farming Practices to ensure sustainability, 2021).
- **Mulching:** It is one of the eco-friendly practices, which involves covering of the farm land by scattering dead plant parts and agricultural residue. Mulching helps to control weed population. It enhances soil health and its water and nutrient holding capacity. On decomposition, the mulch layer adds to the humus content of soil and makes it further healthy and porous (Mishra, 2013).
- **Integrated Pest Management (IPM):** According to this, integrated approach is used for pest and disease control which involves systematic application of eco-friendly physical and biological control methods. Chemical control methods are used only under unavoidable circumstances (What is sustainable agriculture?, 2022).
- **Weed control:** Weeds are the unwanted plants which grow in the fields and compete with main crop and thereby deplete the nutritious resources of the crops. Therefore, weed control becomes extremely essential and can be achieved by using the safe and non-chemical methods like hand picking of weeds, bio control of weeds, simple mechanized weed cutting, etc (Gupta, Pradhan, Jain, & Nayha, 2021).
- **Soil and nutrient conservation and management:** It plays key role in sustainable agriculture as good quality soil enhances hybrid vigour and produces high yields of strong, healthy, disease resistant crops. Tillage reduction, intercropping, cover cropping, mulching, use of wind-breaker systems, soil terracing, use of biological fertilizers, etc. give effective soil conservation and management (Kogut, 2022).
- **Water conservation and management:** Plant cultivation is impossible without water usage. Sustainable water usage involves sufficient plant hydration by optimizing the water and energy consumption. This can be achieved by various practices like use of ground cover, mulching, drip irrigation, mataka sinchan, use of drought tolerant local crops, etc. Well-planned, efficient irrigation systems function through irrigation scheduling, water return systems, and improved pump efficiencies (What ecofriendly farming ideas, can you adopt?, 2017).

- **Effective landscape management:** It is a sustainable agricultural practice of purposefully maintaining uncultivated or less intensively farmed lands around the crop fields. It refers to the holistic landscape and crop management. These uncultivated land strips minimize soil and nutrient erosion, enhance soil microflora activity, attract pollinators, and conserve biodiversity of flora and fauna (Kogut, 2022).
- **Packaging and transportation management:** At post-harvest management level also, the care needs to be taken to fulfill the sustainability goals. Innovative, reusable, biodegradable or recyclable materials like paper bags, stretch films, strapping, woven poly bags, gunny bags, jute bags, cotton bags, etc. should be selected for packaging. Selling of the produce in the nearby local markets saves energy, packaging hassles and transportation cost and thereby makes the community self-sufficient and financially stable (What ecofriendly farming ideas, can you adopt?, 2017).
- **Conservation and cultivation of precious older crop varieties:** Industrialization and over-commercialization of food crops has given opportunity only to few crop varieties to be cultivated as food crops. This has reduced the genetic variability in the food crop varieties which has further reduced their tolerance to climate change, pests, and diseases. Besides this has caused greater loss of seed biodiversity. The sustainable solution to this problem is use and cultivation of heirloom and older crop varieties. These are those varieties which have nourished our ancestors. These exhibit greater genetic variability and possess capacity to survive even in unfavorable conditions. Hence, if preserved properly, through their unique traits, they would become ideal food crops nourishing the future generations (Eco-friendly Farms, 2022).
- **Awareness creation:** This is an equally required step towards sustainable agriculture. This can be achieved by informing and encouraging farmers to adopt sustainable agro-practices, providing the farmers required trainings and guidance, arranging market for sustainable crop produce, recognizing the corporations that buy sustainable crops, restructuring government support to farmers, strengthening the linkage between and farmers and consumers, educating consumers about the usage and benefits of sustainable agriculture and its products and so on (Howell, 2022).
- **Use of satellite technologies:** Horticultural industries and enterprises, National and international traders, governmental and environmental bodies, statistical agencies, etc. require precise and timely updates on crops at pre-harvest and post-harvest levels. Use of satellite technologies like remote sensing offers a reliable, sustainable option for predicting and analyzing resource usage, soil health, crop diversity, production, its further processing, storage, transportation, etc. It might be costlier affair in the early phases but later becomes sustainable, cost-effective option as it saves on energy, time, money, etc. (Kogut, 2022).

CONCLUSION

Against the backdrop of the environmental harm and damage happened so far, it is the extreme need of the hour to adopt innovative, eco-friendly sustainable agro-practices. Thus, sustainable agriculture would play vital role to ensure world's nutrition security in a climate-constrained scenario and would thereby protect and profit the environment and farmers but also would promote social and economic equity.

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Chapter **15**

ORGANIC FARMING IN INDIA: EMBRACING SUSTAINABLE AGRICULTURE

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ABSTRACT

The production of safe and wholesome food as well as ecological balance and soil health are all prioritized by organic farming, which is a crucial part of sustainable agriculture in India. As more individuals become aware of the food they and their family members consume, the importance of health benefits is growing. Consequently, there is a level for products created by organic farming. Quality local produce, heartbeats, and organic goods were once expensive. A long life and a stable manner of living resulted from this. The benefits, difficulties, and current state of organic farming in India are discussed in this article.

KEYWORDS: Organic farming, sustainable agriculture, market access, small-scale farmers.

INTRODUCTION

Organic farming is a sustainable agricultural system that relies on ecological principles to maintain soil health, plant and animal health, and environmental quality. Organic farmers use crop rotations, cover crops, and other practices to build soil organic matter and fertility. They also use biological pest controls and fertilizers derived from plant and animal wastes. There are many benefits to organic farming. Organic food is typically higher in nutrients than conventionally grown food. It is also produced without the use of synthetic pesticides, herbicides, and fertilizers, which can pollute the environment and harm human health. Organic farming can also help to conserve water and soil resources. Organic farming prioritizes the well-being of both the consumers and the farmers. By eliminating the use of synthetic chemicals, it aims to provide healthier and safer food options for consumers, free from potentially harmful residues. Organic farming also supports the livelihoods of farmers by reducing their dependency on expensive agrochemicals and providing opportunities for value addition and market diversification. The organic farming movement has gained significant momentum globally as people recognize the importance of sustainable and environmentally friendly food production systems. In many countries, organic farming is supported by regulations and certification programs that ensure adherence to specific standards and practices. In India, organic farming is steadily gaining popularity. The country has a long history of traditional and organic agricultural practices, with many farmers following age-old techniques rooted in ecological wisdom. The Indian government, recognizing the potential of organic farming, has introduced various schemes and initiatives to promote and support organic agriculture. While organic farming presents numerous benefits, it also poses challenges. Farmers need to acquire knowledge and skills to effectively implement organic practices, and market linkages need to be strengthened to ensure fair prices for organic produce. Additionally, the transition from conventional to organic farming requires careful planning and investment.

PRINCIPLES OF ORGANIC FARMING

The principles of organic farming are based on the following concepts:

- **Sustainability:** Organic farming systems must be sustainable over the long term. This means that they must be able to maintain soil health, plant and animal health, and environmental quality without depleting natural resources.
- **Ecological balance:** Organic farming systems must promote ecological balance. This means that they must work with nature, rather than against it, to create healthy and productive ecosystems.
- **Health:** Organic food must be healthy for people to eat. This means that it must be free of synthetic pesticides, herbicides, and fertilizers, which can have harmful health effects.
- **Fairness:** Organic farming systems must be fair to farmers and workers. This means that they must provide fair wages and working conditions, and they must protect the rights of farmers and workers.

PRACTICES OF ORGANIC FARMING

There are many different practices that can be used in organic farming. Some of the most common practices include:

- **Crop rotations:** Crop rotations help to maintain soil health and fertility. By rotating crops, farmers can help to prevent the buildup of pests and diseases, and they can also help to improve the soil's ability to retain nutrients.
- **Cover crops:** Cover crops are planted between cash crops to help improve soil health. Cover crops can help to prevent erosion, improve soil structure, and add organic matter to the soil.
- **Organic fertilizers:** Organic fertilizers are used to provide nutrients to crops. Organic fertilizers can be derived from plant and animal wastes, as well as from compost.
- **Biological pest controls:** Biological pest controls are used to control pests and diseases in organic farming systems. Biological pest controls can be derived from plants, insects, or microorganisms.

STATUS OF ORGANIC FARMING

According to the National Centre for Organic and Natural Farming (NCOF), the average profit margin for organic farming in India is 20-30% higher than for conventional farming. This is because organic farmers typically receive higher prices for their products, and they also have lower input costs.

For example, a study by the Indian Institute of Management Ahmedabad found that organic farmers in Gujarat were earning an average profit of 25%, compared to 15% for conventional farmers. The study also found that organic farmers had lower input costs, as they did not need to use synthetic pesticides or fertilizers.

The profitability of organic farming in India is expected to increase in the future, as the demand for organic food continues to grow. In 2022, the market size of organic food in India was estimated to be $1.2 billion, and it is expected to reach $4.08 billion by 2028.

HERE ARE SOME OF THE FACTORS THAT ARE DRIVING THE GROWTH OF THE ORGANIC FOOD MARKET IN INDIA

1. Increasing awareness of the health benefits of organic food
2. Growing concerns about the environmental impact of conventional farming
3. Government support for organic farming

As the demand for organic food continues to grow, the profitability of organic farming in India is likely to increase. This will provide an opportunity for farmers to improve their incomes and livelihoods, and it will also help to protect the environment.

The Government of India provides assistance for promoting organic farming across the country though different schemes.

1. The Pkvy programme for paramparagat krishi

The Participatory Guarantee System (PGS)-certified Paramparagat Krishi Vikas Yojana encourages cluster-based organic farming. Under the plan, cluster formation, training, certification, and marketing are supported. A farmer receives financial assistance of Rs. 50,000 per ha for three years, of which 62% (Rs. 31,000) is given as a financial incentive to use organic inputs.

2. MOVCDNER, or the Mission Organic Value Chain Development for the North Eastern Region

Through Farmer Producer Organisations (FPOs), the programme encourages third-party certified organic growing of specialty crops in the north-eastern region with an emphasis on exports. For three years, farmers are offered financial help of Rs 25,000 per hectare for organic inputs such as Biofertilizers, organic manure, and other inputs. The scheme also offers support for the establishment of FPOs, capacity building, and post-harvest infrastructure up to Rs 2 crores

3. National Mission on Oilseeds and Oil Palm (NMOOP)

Under the Mission, financial assistance at 50 percent subsidy to the tune of Rs. 300 per hectare is being provided for different components including bio-fertilizers, supply of Rhizobium culture, Phosphate Solubilizing Bacteria (PSB), Zinc Solubilizing Bacteria (ZSB), Azatobacter, Mycorrhiza and vermi compost.

4. National Food Security Mission (NFSM)

Under NFSM, financial assistance is provided for promotion of bio-fertilizer (Rhizobium/PSB) at 50 percent of the cost limited to Rs 300 per hectare.

As per international resource data from **Research Institute of Organic Agriculture** (FiBL) and the **International Federation of Organic Agriculture Movements** (IFOAM) Statistics 2020, India stands at 9th position in terms of certified agricultural land with 1.94 million hectare (2018-19).

Organic Certification and marketing- In India right now, there is a steadily expanding demand for organic food, and customers are seeking for certified items to ensure the quality of organic food. There are now two different types of certification systems in India, the first of which is the Third Party Certification (NPOP) system, which is administered by APEDA and the Ministry of Commerce and is mostly utilised for export purposes.

5. PGS-INDIA certification system.

PGS-India is overseen by the Ministry of Agriculture and Farmers Welfare and focuses mainly at domestic and local markets. Small and marginal farmers are unable to apply for certification from third parties since it requires extra paperwork and costly fees. The Participatory Guarantee System (PGS)-INDIA natural certification device turned into brought in 2011 via way of means of the Department of Agriculture and Cooperation and Farmers Welfare, Government of India, to make it simpler, greater affordable, and less difficult for greater small and marginal farmers to undertake certification and promote their produce domestically. The application's implementation is on the whole the duty of the National Centre for Organic Farming (NCOF) in Ghaziabad and its 5 Regional Centers, which function Zonal Councils and are positioned in Ghaziabad (HQ), Bangalore, Nagpur, Bhubaneswar, and Imphal. The Leader Secretary of the PGS-INDIA Framework and the PGS-INDIA Secretariat are each NCOF. Ensuring that everyone PGS-INDIA application physical games are finished as in line with PGS tips is one in all its vital obligations.

BENEFITS OF ORGANIC FARMING

There are many benefits to organic farming. Some of the most important benefits include:

1. **Healthier food**: Organic food is typically higher in nutrients than conventionally grown food. It is also free of synthetic pesticides, herbicides, and fertilizers, which can have harmful health effects.
2. **Environmental protection**: Organic farming can help to protect the environment. Organic farming systems can help to conserve water and soil resources, and they can also help to reduce pollution.
3. **Sustainability**: Organic farming systems are designed to be sustainable over the long term. This means that they can be used to produce food without depleting natural resources.
4. **Fairness:** Organic farming systems can help to promote fairness for farmers and workers. Organic farmers typically receive higher prices for their products, and they also have more control over their farming practices.

FUTURE OF ORGANIC FARMING

The future of organic farming is bright. The demand for organic food is growing, and there is a growing awareness of the benefits of organic farming. As more people learn about the benefits of organic farming, the demand for organic food is likely to continue to grow.

CONCLUSION

Organic farming is a sustainable agricultural system that has many benefits. It produces healthier food, protects the environment, and is fair to farmers and workers. The future of organic farming is bright, and as more people learn about the benefits of organic farming, the demand for organic food is likely to continue to grow. Organic farming is gaining momentum in India as a sustainable and environmentally friendly approach to agriculture. It offers numerous benefits, including safe food production, ecological conservation, and improved farmer livelihoods. Addressing challenges related to awareness, certification, and market access will be pivotal in further promoting and scaling up organic farming practices, contributing to a sustainable and resilient agricultural future in India.

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Chapter
16

ETHNOBOTANICAL STUDY OF MEDICINAL FLORA IN SHEOPUR DISTRICT (MP): A REVIEW

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ABSTRACT

Ethnobotany is a distinct branch of science dealing with various aspects of botany, ecology, economics, medicine, religion, cultural archaeology, and several other disciplines. Recently, in worldwide level a great interest has been developed in the studies of herbal drugs and traditional remedies to cure people. The present review highlights useful ethnobotanical information about the uses of plants by the tribals of Sheopur district. This ethno-wisdom is helpful for scientific studies and human welfare.

KEYWORDS: Ethnobotany, tribals, indigenous system, ethnomedicine.

INTRODUCTION

Ethnobotany is the study of relationship between plants and animals. It combines the disciplines of botany (the study of plants) and anthropology (the study of human societies and cultures) to investigate the traditional knowledge and practices surrounding the use of plants by different communities around the world.

"Ethnobotany" term is given by An American botanist J.M. Harshberger in 1895. It reflects the essence of the field, with "ethno" referring to the cultural or ethnic aspect and "botany" emphasizing the study of plants. Ethnobotanists develop into the ways in which indigenous and traditional communities perceive, interact with, and utilize plants for various purposes, including medicinal, cultural, ceremonial, and spiritual uses. One of the primary goals of ethnobotany is to document and preserve traditional knowledge systems related to plants. Indigenous cultures have a deep understanding of local flora and have developed sophisticated systems of plant classification, cultivation techniques, and methods for extracting and preparing plant-based remedies. This knowledge, passed down through generations, is an invaluable cultural heritage that holds immense potential for addressing current challenges in healthcare, conservation, and sustainable resource management. Ethnobotanical research involves close collaboration with indigenous communities, as it recognizes the importance of their perspectives, experiences, and wisdom. Ethnobotanists work in partnership with these communities to study their traditional plant knowledge, practices, and belief systems, often employing methods such as interviews, participant observation, and field surveys.

HISTORY OF ETHNOBOTANY

Ethnobotany is a multidisciplinary field that explores the relationship between plants and people, specifically focusing on how different cultures and societies have used plants for various purposes throughout history. The history of ethnobotany is closely intertwined with the history of human civilization and can be traced back to the earliest records of human plant interactions.

Early Human Plant Interactions: The origins of ethnobotany can be traced back to prehistoric times when early humans began to rely on plants for their sustenance. They started gathering wild plants for food, and over time, they learned which plants were edible, medicinal, or useful for other purposes. This knowledge was passed down through generations orally.

Ancient Civilizations: As human societies developed and civilizations emerged, the understanding and use of plants became more sophisticated. Ancient civilizations such as the Egyptians, Sumerians, Greeks, and Romans recognized the medicinal properties of various plants and developed systems of herbal medicine. These early cultures documented their knowledge of plants in texts and manuscripts, which became valuable sources for later studies in ethnobotany.

Indigenous Knowledge: Indigenous cultures around the world have played a crucial role in shaping the field of ethnobotany. Indigenous communities possess deep knowledge about their local flora and have developed intricate systems of plant classification, use, and conservation. Their traditional knowledge has contributed significantly to the understanding of plant properties, medicinal applications, and ecological relationships.

Exploration and Colonial Period: The Age of Exploration and colonialism brought European explorers and scientists into contact with diverse plant species and indigenous knowledge systems. During this period, European botanists, such as Carl Linnaeus and Joseph Banks, began to document and classify plants from different regions. They interacted with indigenous peoples and learned about the traditional uses of plants, which further enriched the field of ethnobotany.

Modern Developments: In the 19th and 20th centuries, ethnobotanical research gained momentum as scientists started conducting systematic studies on the traditional plant knowledge of various cultures. Prominent ethnobotanists like Richard Evans Schultes, Wade Davis, and Mark Plotkin conducted extensive fieldwork in remote regions, particularly in the Amazon rainforest, to document indigenous plant knowledge and the uses of medicinal plants.

Ethnobotany Today: In the present day, ethnobotany continues to evolve as a scientific discipline that combines traditional knowledge with modern scientific methods. Ethnobotanical research focuses on areas such as medicinal plant discovery, conservation of traditional knowledge, sustainable harvesting practices, and the exploration of plant potential for food, fibres, dyes, and other applications. It also addresses the cultural significance of plants and the importance of preserving traditional practices and knowledge systems.

There have been several notable Indian ethnobotanists who have made significant contributions to the field of ethnobotany. Here are a few examples:

1. **Dr. Janaki Ammal (1897-1984):** Dr. Janaki Ammal was an eminent Indian botanist and ethnobotanists known for her extensive research on plant Cytogenetics and ethnobotany. She conducted extensive fieldwork, documenting the traditional uses of plants by indigenous communities, particularly in South India. Her work contributed to the understanding of plant diversity, conservation, and traditional knowledge systems. She is known as mother of Indian ethnobotany.

2. **Dr. Shantaram G. Hegde (1948-2014):** Dr. Hegde was a renowned Indian ethnobotanist who specialized in the study of medicinal plants. He conducted extensive field surveys across India, documenting traditional medicinal plant knowledge. Dr. Hegde's research focused on the identification of medicinal plants, their conservation, and the development of sustainable practices for their use.
3. **Dr. S.K. Jain (1930-2015):** Dr. S.K. Jain was a prominent Indian botanist and ethnobotanist known for his contributions to the study of traditional medicine and ethnobotanical research. He extensively documented the traditional uses of medicinal plants by various indigenous communities in India. Dr. Jain's work helped bridge the gap between traditional knowledge and modern science, emphasizing the importance of integrating traditional medicine into healthcare systems. He is known as father of Indian ethnobotany.
4. **Dr. N. Rama Swamy (born 1941):** Dr. Rama Swamy is a renowned Indian ethnobotanist known for his work on the traditional knowledge and uses of medicinal plants. He has conducted research on tribal communities in the Eastern Ghats region of India and has made significant contributions to the documentation and conservation of traditional knowledge related to medicinal plants.
5. **Dr. Vandana Shiva (born 1952):** Dr. Vandana Shiva is an environmental activist, author, and scientist who have made substantial contributions to the field of ethnobotany and sustainable agriculture. She has worked extensively on the preservation of indigenous knowledge, seed conservation, and sustainable farming practices in India. Dr. Shiva's work emphasizes the importance of traditional agricultural practices and their role in promoting food security and environmental sustainability.

AIMS AND OBJECTIVES OF ETHNOBOTANY

- Proper documentation of indigenous knowledge about medicinal plant.
- Preservation of unwritten traditional knowledge about herbal plants.
- Conservation of our national heritage before its extinction.
- To create awareness about its role in cultural, social health of people.
- To train people or students for utilization and conservation of medicinal plants.
- To increase in manufacture of herbal drugs.
- Research and job opportunities.

Sheopur is a district of Madhya Pradesh in Central India. The district is located in the north of the state and forms part of Chambal division. It is situated in the latitude of 25^0 39′ 52.99″ N and longitude of 76^0 41′46.18″ E, on the periphery of Rajasthan, which shows in the influence of Rajasthani culture in this district. It is the third least populous district of Madhya Pradesh, after Harda and Umaria in 2011 census. It is one out of 20 tribal districts of Madhya Pradesh. Sheopur has a rich diversity of flora and fauna. Saharia is the main tribe of this region and some other tribe like bheel and bhilala are also found in Karahal block of this district.

Kuno National Park is a national park in Madhya Pradesh, India, established in 1981 as a wildlife sanctuary with an initial area of 344.686 km2 (133.084 sq. mi) in the Sheopur and Morena districts. In 2018, it was given the status of a national park and its area extends up to 748.76 km2 (289.10 sq. mi). It is part of the Khathiar-Gir dry deciduous forests ecoregion. The eight cheetahs, shifted from

Namibia to Madhya Pradesh's Kuno National Park (KNP) on September 17. This cheetah project is very helpful for upliftment of the economic conditions of tribal people. This project gives employment to tribal youth in local level in tourism sector, hotel industries and automobile industries.

Table 1: List of Some Important Ethnomedicinal Plants in Sheopur

S.No.	Plant name	Botanical name	Part used	Medicinal use
1.	Adusa	*Adhatoda vasica* (Acanthaceae)	Leaves	Joint pain, cough
2.	Gaurpatha	*Aloe barbedensis* (Liliaceae)	Leaves	Liver, spleen, eye, and skin diseases
3.	Girmala	*Cassia fistula* (Fabaceae)	Fruit(pod)	Constipation and diabetes
4.	Ashgandh	*Withania somnifera* (Solanaceae)	Dry root	Haematological problems
5.	Amarbel	*Cuscuta reflexa* (Convolvulaceae)	Leaves	Leucoderma
6.	Marorphali	*Helicteres isora* (Sterculiaceae)	Fruit and seed	Amoebiosis
7.	Kalmegh	*Andrographis paniculata* (Acanthaceae)	Whole plant	Stomach, cholera
8.	Patharchatta	*Boehravia diffusa* (Nyctaginaceae)	Whole plant	Urinary troubles and kidney stone
9.	Gokhru	*Tribulus terestris* (Zygophyllaceae)	Fruit	Urinary troubles, Haematuria
10.	kaner	*Nerium odoratum* (Apocynaceae)	Root	Sinus
11.	Mahua	*Madhuca longifolia* (Sapotaceae)	Bark, flower, leaf	Skin disease, rheumatism, piles, constipation
12.	Bael	*Aegle marmelos* (Rutaceae)	Leaf, Fruit	anti-diabetic, anti-microbial, anti-inflammatory,
13.	Tendu	*Diospyros melanoxylon* (Ebenaceae)	Leaf, Bark	Antimicrobial, anti-hyperglycaemic
14.	Guggul	*Commiphora wightii* (Burseraceae)	Leaf, Bark	antioxidant, antibacterial, antitumor
15.	Salai	*Boswellia serrata* (Burseraceae)	Leaf, Bark	anti-inflammatory, anti-arthritic
16.	Arjun	*Terminalia arjuna* (Combretaceae)	Roots, Bark Fruits	diarrhoea, asthma, and cough.

17.	Jungle jalebi	*Pithecellobium dulce* (Fabaceae)	Leaf, Bark	Promotes Weight Loss, Cures Gut Problems, Manages Diabetes Symptoms.
18.	khair	*Acacia catechu* (Fabaceae)	wood	Diarrhoea, eruptions of the skin, leprosy, anaemia, Leucoderma.
19.	Bahera	*Terminalia bellerica* (Combretaceae)	Bark, fruits	Leprosy, skin diseases, vomiting, bronchitis.

IMPORTANCE OF ETHNOBOTANY

1. **Conservation of plant diversity**: Ethnobotanical knowledge plays a crucial role in the conservation of plant species and ecosystems. Indigenous communities have developed intricate knowledge about local plant species, their habitats, and sustainable harvesting techniques over centuries. By studying and documenting their traditional knowledge, we can gain valuable insights into the conservation and sustainable use of plant resources.
2. **Medicinal discoveries**: Ethnobotany has been instrumental in the discovery and development of numerous medicinal compounds. Many modern medicines have their roots in traditional plant-based remedies. Ethnobotanical studies help identify potential medicinal plants and guide the search for bioactive compounds, leading to the development of new drugs and treatments.
3. **Cultural preservation**: Ethnobotany is closely linked to the cultural heritage and traditional practices of indigenous communities. By studying and preserving their knowledge, we can contribute to the preservation of cultural diversity and help maintain cultural identities. It also helps bridge the gap between traditional knowledge and modern science, fostering respect and understanding between different cultures.
4. **Sustainable resource management**: Indigenous communities have traditionally practiced sustainable harvesting and management of plant resources. Their knowledge and practices can provide valuable insights into sustainable agriculture, forestry, and land management techniques. Ethnobotanical studies help us understand traditional ecological knowledge systems and integrate them into modern approaches to ensure the sustainable use of natural resources.
5. **Food security and nutrition**: Ethnobotany provides insights into traditional food systems and the diversity of edible plants used by different cultures. This knowledge can contribute to addressing issues of food security, promoting crop diversity, and improving nutritional outcomes. Additionally, traditional agricultural practices and crop varieties adapted to local conditions can be valuable resources for climate change adaptation.
6. **Economic opportunities**: Ethnobotanical knowledge can create economic opportunities for indigenous communities and local populations. By recognizing the value of traditional knowledge and supporting sustainable practices, communities can engage in activities such as sustainable harvesting, cultivation of medicinal plants, ecotourism, and the development of value-added products, leading to income generation and poverty alleviation.

CONCLUSION

Ethnobotany is essential for the conservation of plant diversity, the discovery of medicinal compounds, the preservation of cultural heritage, and the sustainable management of resources, addressing food security, and creating economic opportunities. By integrating traditional knowledge with modern science, we can promote sustainable development, enhance cultural diversity, and support the well-being of both people and the environment.

So, we can say that ethnobotany plays a very important role in the upliftment of tribal communities because they living in backward areas where super medical facilities are not available. Now due to urbanization and industrialization, displacement and deforestation is very much affecting the forest area and along with tribal communities is thought to be vanished in near future. So, in order to keep our planet green and live we need to go back to our traditional culture and heritage, which gives us lesson of sustainable development with limited and balance use of natural resources without destroying them to make them available for future generations. Now this is the time to make tribal youths aware about use and benefits of this indigenous medicine system. Documentation of ethnomedicinal knowledge and adoption of it as carrier option among tribal youth. So, it is helpful for cultural legacy and economic upliftment and sustainable development of the tribal society. Ethnomedicine is also play a very important role in new drug discovery.

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Chapter 17

APPLICATION OF BIOENZYME PREPARED FROM WASTE ORANGE FRUIT PEELS (*CITRUS SINENSIS* AND *CITRUS LIMON*)

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ABSTRACT

In recent years there are several researches are undergone to determine the usage of Biofertilizers and world farmers and most of the peoples are turning towards organic farming. In this scenario the Bioenzymes is natural and effective solution for all the physiological preparations of soil and its biodiversity. The current study is based on the mass cultivation of swamp mallows by using bioenzyme as fertilizer. The bio enzymes are nontoxic, nonhazardous, non-corrosive, ecofriendly and completely natural liquid. They are easily synthesized by anaerobic fermentation by using jaggery and plant waste (orange peels or used scented flowers etc) and water along with microorganisms of a small quantity in plastic containers. These Bioenzymes were treated with *Hibiscus rosa sinensis* for the analysis of growth parameters such as height of the plants and no of leaves etc. As Bio-enzymes are of great importance which is in general created out of waste and turns out to be an excellent economical feasible to the people and the end product is sustainable to the nature which enhances the quality of life as a whole.

KEYWORDS: Bioenzymes, Citrus fruits, Biofertilizers, Insecticides, Pesticides.

INTRODUCTION

The Enzymes which are produced by the microbes in a biological environment is generally termed as Bioenzymes. The Bio enzyme is completely natural and biodegradable multipurpose Product which is produced by fermenting citrus peels with jaggery and water in a required proportion. It a multipurpose product it is used as floor cleaner, as a detergent for cloth even washing utensils, as a body wash and Hair shampoo. It is also a natural Biofertilizers for crops, which promote strong healthy flowers and good quality fruits and vegetables. Apart from this, citrus enzyme can be used as facial cleaner, clean greasy surface, hair conditioner, insect repellent, drain and sewage cleaner (1 Litre of Bio enzyme can clean approx. 1000 Litre of sewage water). Bio enzyme has the power to remove unpleasant odor from air and purify it. Also eliminated odor from drainage pipes and also smell of tobacco. During the present time, the trend of organic farming has increased a lot. The people have found out many alternate modes of growing these crops at home or even in farms by utilizing renewable resources such as Bio enzymes which they prepare at home in order to combat the environmental issues caused by pesticides, insecticides, etc. Somehow, this trend could be in fashion nowadays as people have started growing in their balconies and rooftop gardens. So, this study is also an attempt to carry out such kind of exploration where we have carried out Bio enzymes preparation which we have utilized in observing the change in growth of the flowering plants using the prepared Bio enzymes. India is blessed with a rich heritage of traditional medical systems and rich biodiversity to complement the herbal needs of the treatment administered by these traditional medical systems. The recognized Indian systems of Medicine are Ayurveda, Siddha and Unani, which use herbs and minerals in the formulations. India which uses 15 agro-climatic zones, 4700 plant species of which 15000 are reported to have medicinal properties varying degrees. The current plant sample taken to study is related to the morphological parameters is on the herb Hibiscus rosa-sinensis Linn [Malvaceae] is a glabrous shrub widely cultivated in the tropics as an ornamental plant and has several forms with varying colours of flowers. In medicine, however, the red flowered variety is preferred (Jadhav *et al.*, 2009).

MATERIALS AND METHODS

COLLECTION OF PLANTS

The investigation was carried out by the preparation of bioenzymes. The present study was to investigate the effect of bioenzymes in the morphological parameters of hibiscus Rosa sienensis. The undergraduate project was conducted in the Department of Botany for final years group-8. In this aspect the plant saplings were collected from "Shakambari Garden" (Green Covers) No.1 Ramachandra Adithanar Road, Gandhinagar, Adyar Chennai-20, Tamil Nadu, India. The research work was carried out in laboratory No-44in Department of Botany of JBAS College for Women, Chennai-18, Tamil Nadu, India, under the supervision and the guide. The following steps were adopted to carry out the research work further. The plant saplings of Hibiscus were collected from the Shakambari Garden (Green Cover) No: 1 Ramachandra Adithanar Road, Gandhinagar, Adyar, Chennai-20, Tamil Nadu, and India.

DESCRIPTION OF PLANT

Hibiscus Rosa sinesis
Vernacular Name
Eng-Shoe-flower plant, Tam-Sapattuu, Hindi- Jasut
Systematic position
Class: Magnoliopsida
Order: Malvales
Family: Malvaceae
Genus: Hibiscus L.
Species: *H. rosa-sinensis*

The herb *Hibiscus rosa sinensis* L. (Malvaceae) is native to China. Many species of Hibiscus are grown for their showy flowers. It is a shrub widely cultivated in the tropics as an ornamental plant and has several forms with varying colours of flowers. Hibiscus has also medicinal properties and takes part as a primary ingredient in many herbal teas. The red flowered variety is preferred in medicine.

There were various studies reported that variety of Hibiscus plants have different medicinal Properties. The leaves and flowers are observed to be promoters of hair growth and aid in healing of ulcers. Flowers have been found to be effective in the treatment of arterial hypertension and to have significant antifertility effect. According to traditional texts it is well accepted that the leaves and flowers of *Hibiscus rosa-sinensis* have hair growth promoting and antigreying properties. Moreover, in India the herbal products in the market intended for hair growth include the extract of various parts of *Hibiscus rosa-sinensis* (Jadhav *et al.*, 2009). Hibiscus grows in tropical areas throughout the world, and has been used not just as anornament, but also medicinally for centuries. The part of this plant used medicinally is the flower. The Hibiscus flower is made into a tea in numerous cultures throughout the world. Hibiscus has a mild flavor and has many culinary uses. A study on *Hibiscus rosa sinensis* reveals that floral senescence is associated with the up regulate/ion of many hydrolytic genes, including aspartic and cysteine member species are renowned for their large, showy flowers and those species are commonly known simply as "hibiscus", or less widely known as rose mallow. Other names include hardy hibiscus, rose of sharon, and tropical hibiscus. (Vincenta Khristi *et al.*, 2016). An Economic and medicinal properties of the plant is high this Hibiscus plant was taken for the research purpose to grow them using Bioenzymes. Preparations for the Bioenzymes was also done in the Laboratory of JBAS College by using the waste orange peel which was bought from the juice shop outside the college campus/ Other materials such as jiggery and yeast was purchased from the grocery shop and distilled ordinary tap water was utilized for mixing.. The potting mix was prepared using the red soil, sand, coco peat and vermicomposting in 1:1:1 ratio. (Table: 1 and Table: 2)

Table 1: Materials for Potting mix for growing the Hibiscus plant

S.No	Materials	Quantity
1	Red Soil	10 Kg
2	Sand	5 Kg
3	Manure (Vermicompost)	10 Kg
4	Cocopeat	5 kg

Table 2: Materials required for Preparation of Bioenzymes

S.No	Materials	Quantity
1	Water Bottle	10LTR
2	Orange Peel	1800gm
3	Jaggery	600gm
4	Dry Yeast	5 gm

PREPARATION OF POT MIX

For the preparation of pot mix the collected materials such as the red soil of about 10 kg and the manure (Vermicompost) and Cocopeat 5 kg was bought as a brick which was kept in a tub containing 2400ml of water for about 24 hrs to loosen its fibre. The next day the soil was made into 2 slots as one as treated and the other as control. The loosened fibre Cocopeat was divided equally in 2 halves and mixed equally in both the slots of soil along with which the manure (10kg) was mixed in the soil mixture in the proportion of 1Part of soil:1 part of cocopeat:1part vermicompost along with required amount of water respectively. Then this soil mixture was allowed to dry for aeration for about 48 hrs and the soil mixture was made into fine particle and filled in pots with the calculation of 500 kg in each pot and the sapling were sown and allowed to grow from the prepared pot mixture (Table 2).

PREPARATION OF BIO ENZYME-METHODOLOGY

The preparation of Bioenzymes is by adopting the Formula-15:10:3:1 where the 15 litres of wide bucket is filled with 10 litres of tap water then 600 gms of powdered jaggery is added and 1800 gms of washed and cleaned orange peel is added into it and later a 5 gms of dry yeast is added to and then the container is left over. The bioenzymes undergoes two processes while its duration of preparation in which first 30 days for aerobic fermentation methods. In this every day the bottle has to open and closed immediately this is to be done for 30 days thoroughly. The second period is anaerobic fermentation method where the bottle has to be remained closed for the period of 60 days. The total period for Bioenzyme preparation is 90 days. This Bioenzymes is a multipurpose agent which can be used for cleaning utensils, cleaning tiles, bathrooms, toilets, sinks, washing clothes, and also as face wash, body wash and shampoo room spray as an air purifier and many more etc.

The prepared Bioenzyme is filtered and the filtrate is separated and liquid is separated. The liquid is added in 1:10 ratio with one part of Bioenzyme and used for all purpose. In this study this Bioenzyme is used as a fertilizer which is added in one treated slot. Periodical check was done to check the morphological parameters of the shoot length and number of leaves and number of flowers.

EXPERIMENTAL STUDY FOR CALCULATING THE GROWTH PARAMETERS IN POT STUDY

The experimental work as carried by taking 20 pots (30 cm of height and 15 cm of breath) of equal size were in 10 kg manure and 10kg of red soil and 10 kg cocopeat and sand in equal proportion was filled in each of the pots and 10 pots were treated with bioenzyme and other 10 pots without treating without Bioenzyme as slot 1 treated and slot control respectively.

PROPAGATION OF HIBISCUS PLANTS

The plants were left in the pot to grow in the herbal garden of Justice Bahseer Ahmed Sayeed College for Women Chennai, Tamilnadu. India. The growth and other physiological effects of bioenzyme were observed in the duration of 60 days. The propagation was simple hand propagation where the plant saplings were uprooted and placed in the pots with prepared pot mix along with the bioenzymes treatment in few and the plants were allowed to grow.

RESULTS AND DISCUSSION

In pilot study half the plants were treated with bioenzyme and the half was left to grow naturally. In this study it was observed that plants treated with bioenzyme showed rapid growth and had longer stems and more number of leaves than those which were left to grow naturally (Table 3, 4 and 5).

The morphological parameters of hibiscus treating with bioenzyme are a piolet study. This study showed the positive effect in treated plants of bioenzyme a rapid growth of flowers, leaves, size of the plant compared to the non-treated plants.

Table 3: Showing the morphological parameters of Swamp Mallows (Hibiscus)

Sr. No.	Plants	Number of Leaves	Stem Length (cm)	Number of Buds	Number of Flowers
1	Red Hibiscus Untreated(P1)	22	10	5	3
2	Red Hibiscus Untreated (P2)	20	12	8	7
3	Red Hibiscus Treated(P3)	25	13.5	11	9
4	Red Hibiscus Treated(P4)	32	17	21	15

Table 4: Showing morphological parameters of red hibiscus treated with bioenzyme after every 15 days

Morphological Parameters	15	30	45	60
Number of Leaves	14	25	38	57
Stem Length (cm)	12	15	20	30
Number of Buds	6	18	24	32
Number of Flowers	3	12	18	24

Table 5: Showing morphological parameters of red hibiscus left untreated after every 15 days

Morphological Parameters	15	30	45	60
Number of Leaves	14	22	34	42
Stem Length(cm)	12	18	20	22
Number of Buds	3	5	9	13
Number of Flowers	Nil	2	5	10

The investigation shows the positive reports when the plants were subjected to bioenzymes. The following discussion was carried out to obtain the results. The use of bioenzymes has enhanced the growth of plants than usual growth and this study is a preliminary study and this work is pioneer.

Similar work on bioenzymes have been observed by kajal Singh etal (2020) and they have reported that the use of bioenzymes shows much better growth constantly with the progression of time, increase in number of leaves and also helps in degrading the bio composite components also induces their uptake by plants more rapidly. Further bioenzymes is also employed in analyzing the effect in treatment with fresh water bodies by Bhavani penmatsaetal (2019) reported that usage of bioenzymes in water bodies reduces the level of DO, BOD and COD which was 0.5, 39.5 and 121 before treatment respectively was decreased to 3.7, 9 and 24 respectively within the time of 3 months and helps in widening and storing capacity of water bodies also increases the tree plantation rate.

Bioenzyme is also used in the inhibition and elimination of Escherichia coliO157:H7 reported by eunsoeblimetal (2019) they summarized that sequential treatment using multiple enzymes can be more effective than single enzymes in removing a preformed biofilm. The differential inactivation efficacy depending on the treatment order of multiple enzymes prior to NaClO treatment strongly suggests that it is important for efficient inactivation of E. coli O157:H7 biofilm cells. they also added that proteins exist more commonly than cellulose in the outermost layer of biofilm matrix protecting cells so the enzyme called proteinase k and cellulase significantly inhibits the biofilm formation of *E. coli*. They suggested the appropriate combination and treatment order can increase the versatility and efficiency of enzymes in biofilm control.

Bioenzymes assisted work was done by kajal Jaiswal (2020) they reported that the enzymes are the most acceptable product for researchers to use in green chemistry as they are most effective and can operate under mild reaction condition Considering the advantages of green chemistry, Biocatalysis has significantly substituted conventional chemical approaches in numerous fields, and this replacement may strike even more fields due to recently developing innovations in enzyme engineering.

CONCLUSION

Hence the research has proved the efficacy of the Bioenzymes as a Biofertilizers for the cultivation of the Hibiscus plants by giving more number of flowers and pathogen free plants. This bioenzymes could be used for the cultivation of any plants in general. The study reveals the fact that Bioenzymes were much effective in providing more nutrients to the plants for its faster growth and shortening the budding period hence, giving more flowers in a short time.

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Chapter
18

FROM LAB TO FIELD: THE UNSTOPPABLE BIOTECH REVOLUTION IN AGRICULTURE

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ABSTRACT

In an era marked by a rapidly growing global population and increasing concerns of food scarcity, the necessity of a biotech revolution in agriculture has become undeniable. As the world grapples with the challenge of feeding billions of people while preserving the environment, the application of technology in agriculture emerges as a promising solution. This book chapter explores the profound impact of biotechnology on the agricultural sector, tracing the journey from laboratory discoveries to their practical application in the field. Advancements in biotechnology, such as genetic engineering, molecular biology, and other cutting-edge technologies, have unlocked remarkable potential for addressing the pressing issues of crop productivity, disease resistance, and environmental sustainability. By harnessing the power of these scientific breakthroughs, scientists have been able to develop crops with enhanced traits that withstand harsh growing conditions, combat pests and diseases, and reduce the environmental impact of agriculture. This chapter delves into key biotech applications that have revolutionized agriculture, including the development and implementation of genetically modified organisms (GMOs), precision breeding techniques, and novel approaches to pest and weed control.

KEYWORDS: Biotechnology, Agriculture, Genetic Engineering, Disease Resistance, Environmental Sustainability, Genetically Modified Organisms (GMOS), Precision Breeding, Pest Control, Sustainability, Resilience.

INTRODUCTION

In recent decades, the field of agriculture has witnessed an unstoppable revolution fuelled by biotechnology. From lab-based scientific breakthroughs to real-world applications in the field, biotechnology has transformed the way we produce food and manage agricultural systems. This chapter explores the remarkable journey of the biotech revolution, tracing its path from laboratory discoveries to practical implementations in agricultural practices. By examining key advancements and their impact on crop productivity, sustainability, and global food security, we uncover the unstoppable force of biotechnology in agriculture. Biotechnology, at its core, harnesses the knowledge of genetics and molecular biology to revolutionize agricultural practices. From genetic engineering to precision breeding, the tools and techniques offered by biotech have reshaped the possibilities for crop improvement. This chapter explores how biotechnology, through its transformative capabilities, is reshaping the way we cultivate crops, protect them from pests and diseases, and ensure a sustainable and resilient food supply for a growing population.

GENETIC ENGINEERING: REWRITING THE BLUEPRINT OF CROPS

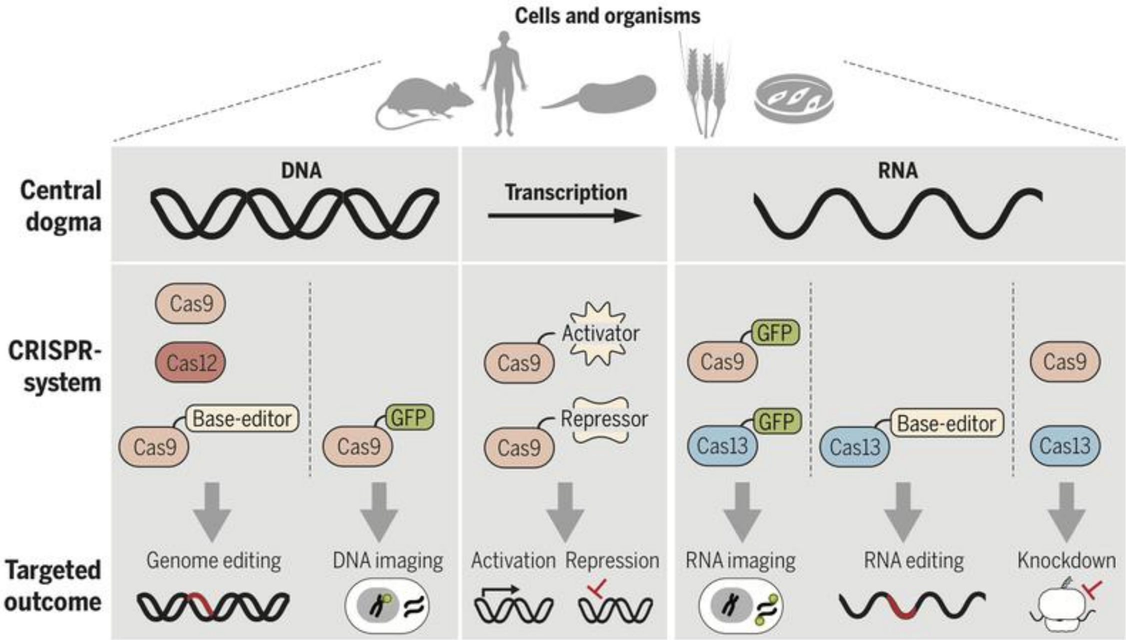
Genetic engineering has enabled scientists to introduce desired traits into plants, enhancing their productivity, nutritional content, and resilience. The traits that may not naturally exist within the plant's genetic composition can therefore be inserted. This trait enables farmers to use herbicides selectively, targeting only the weeds while leaving the crops unharmed. Herbicide-tolerant crops simplify weed control, increase efficiency, and reduce the reliance on mechanical or manual weed management practices. It also helps in improving crop resilience to various environmental stresses. For instance, scientists can introduce genes that enhance drought tolerance, enabling crops to withstand extended periods of water scarcity. Similarly, genes associated with tolerance to extreme temperatures, salinity, or flooding can be incorporated, allowing crops to thrive in challenging environmental conditions. Genetic engineering is instrumental in improving the nutritional content of crops, addressing malnutrition, and enhancing human health. Scientists can modify crops to produce higher levels of essential nutrients such as vitamins, minerals, or specific proteins (Pollan, 1998). This biofortification approach can help combat micronutrient deficiencies and improve the nutritional quality of staple crops consumed by millions of people worldwide.

PRECISION BREEDING: THE ART OF SELECTIVE TRAITS:

Precision breeding, also known as precision agriculture or molecular breeding, is a modern approach to crop improvement that utilizes advanced technologies and genetic information to expedite the breeding process and develop crop varieties with desired traits. Unlike traditional breeding methods that rely on phenotypic selection, precision breeding leverages the understanding of plant genetics and genomics to make informed decisions and achieve more targeted results. Precision breeding techniques, such as marker-assisted selection and genome editing, have revolutionized the process of developing new crop varieties. By targeting specific genes responsible for desirable traits, breeders can accelerate the breeding process and create more resilient, productive, and sustainable crops.

a. **Marker-assisted selection:** It involves the identification and utilization of genetic markers. These markers can be DNA sequences or molecular markers associated with specific genes responsible for the target traits. MAS allows breeders to indirectly select for complex traits that are difficult to assess through direct phenotypic observation alone. For example, drought tolerance or disease resistance may be determined by multiple genes and influenced by environmental factors. With MAS, breeders can select individuals with specific marker combinations associated with the desired trait, increasing the chances of success in breeding programs.
b. **DNA sequencing and genotyping:** By using molecular tools such as DNA sequencing and genotyping, breeders can identify individuals or progeny carrying the desired markers more efficiently, enabling more precise selection and reducing the time required for breeding. These markers serve as signposts along the genome, indicating the presence of genes or gene regions responsible for favourable yield characteristics. By analysing the DNA of different cultivars, landraces, and wild relatives, researchers can identify variations in genes related to yield potential. It also contributes to QTL mapping, which involves identifying the genomic regions associated with quantitative traits, including yield-related traits.it accelerate the breeding process by reducing the time required for trait evaluation and selection.

c. **Genome Editing:** Genome editing techniques, such as CRISPR-Cas9, have revolutionized precision breeding by enabling targeted modifications of specific genes within the plant's genome. There are many naturally occurring CRISPER Cas system of which class II mediates target interference or cleavage (E. V. Koonin, *et al.*, 2017). How genome editing works is shown with the help of diagram by (Knott *et al.*, 2018). With genome editing, breeders can directly introduce, remove, or modify specific DNA sequences with high precision.



a) Cas9 and Cas12a are used for inducing dsDNA breaks for genome-editing.

b) nCas9 can be fused to base-editors to modify nucleotides in dsDNA for genome-editing without introducing a dsDNA break.

c) dCas9 can be fused to transcriptional activators, repressors, or epigenetic modifiers to regulate transcription.

d) Cas9 and Cas13a can be used for targeted RNA interference.

e) Cas13a fused to base-editors can be used to modify nucleotides in ssRNA. f-g) dCas9 or dCas13a can be fused to GFP to image DNA/RNA and RNA, respectively (Knott *et al.*, 2018).

This technology offers unprecedented control over the genetic makeup of crops, allowing for the precise alteration of genes responsible for desired traits. By making targeted edits, breeders can accelerate the development of crop varieties with improved yield potential. Genome editing techniques are particularly valuable for introducing subtle changes or precise modifications without introducing genes from unrelated organisms. This aspect addresses some concerns associated with genetic engineering and promotes greater acceptance of precision breeding techniques.

CROP PROTECTION TECHNOLOGIES: SAFEGUARDING YIELDS

Biotechnology has equipped farmers with innovative tools to protect their crops from pests, diseases, and environmental stressors. Here are some advanced diagnostic tools for rapid and accurate identification of pests, diseases, and pathogens in crops. Molecular techniques such as DNA-based diagnostics and polymerase chain reaction (PCR) assays enable farmers and researchers to detect and monitor specific pests or pathogens more efficiently. Early and accurate detection allows for timely and targeted interventions, reducing the spread of diseases and minimizing crop losses. Biopesticides, RNA interference, and other biotech solutions have reduced reliance on conventional pesticides and enabled sustainable pest management practices.

a. **RNA Interference (RNAi):** RNA interference is a biological process that involves the introduction of small RNA molecules into plants, which can silence specific genes, including those of pests or pathogens. RNAi-based technologies can be used to target insect pests, viruses, and other pathogens, offering a novel approach for crop protection. By interfering with the expression of key genes in pests or pathogens, RNAi can disrupt their life cycles (Sanford and Johnston, 1985), reduce their ability to cause damage, and enhance crop protection. Viruses rely on the cellular machinery of the host to complete their life cycle, and RNAi provides an effective means of disrupting this process (Wang *et al.*, 2012; Katoch and Thakur, 2013; Galvez *et al.*, 2014).
b. **Biopesticides:** Pesticides derived from natural materials such as animals, plants, bacteria, and minerals are considered as biopesticides (EPA,2003). These biopesticides offer targeted control of pests and diseases while minimizing harm to beneficial organisms and reducing chemical residues in food and the environment. Bacteria such as Bacillus thurigenesis, Pseudomonas, Serratia are used in bacterial biopesticides, botanical biopesticides include Azadirachtin. For controlling soil borne diseases Trichoderma and Pseudomonas are widely used (Handelsman and Stabb, 1996). Detailed list of biopesticides, target insects, action mode are documented in the paper Natural Product Based Biopesticides For Insect Control (Gonzalez-Coloma A *et al.*, 2013). Implementing biopesticides in agriculture not only effectively manages plant diseases and pests but also plays a pivotal role in integrated pest management (IPM), leading to significant reductions in the reliance on conventional pesticides while maintaining optimal crop yields. Various disadvantages of conventional chemical pesticides over biopesticides had been studied and presented in table form (Kumar J, *et al.*, 2021)

Conventional Chemical Pesticides	Biopesticides
Synthesised or produced from artificial/chemicals	Use naturally occurring compounds derived from living organisms for the production
They cause environmental pollution and are not eco-friendly	They do not cause environmental harm
Harmful to nontarget organisms	Do not cause harm to nontarget organisms
Cost ineffective	Cost efficient and cheaper, compared to chemical fertilisers
Microorganisms develop resistance gradually as the application increases	Pests do not develop resistance
High market value	Not preferred in the market
Contaminate water and soil	Cannot contaminate water sources
Lead to bioaccumulation	Do not lead to bioaccumulation

RESHAPING AGRICULTURAL PRACTICES

The biotech revolution has permeated every aspect of agricultural practices. From precision farming and smart irrigation systems to data-driven decision-making. Data-driven decision-making refers to the practice of using data and analytics to inform and guide decision-making processes within the biotechnology industry. It involves collecting, analysing, and interpreting large volumes of data from various sources, such as experimental results, genomic sequences, clinical trials, and other relevant data sets.

a. By collecting and analysing data on soil characteristics, nutrient levels, moisture content, and weather patterns, farmers can make informed decisions regarding the precise application of fertilizers, irrigation, and other inputs. This allows for targeted interventions and resource optimization, minimizing waste and maximizing yield potential.

b. It is crucial for understanding market trends, consumer preferences, and supply chain dynamics in agriculture. By analysing market data, pricing trends, and consumer demands, farmers can make informed decisions regarding crop selection, production volumes, and marketing strategies. assist in managing risks in agriculture, such as weather-related risks, market fluctuations, and crop diseases.

c. By analysing historical weather data, market information, and crop performance data, farmers can assess and mitigate risks associated with these factors. This allows for the implementation of risk reduction strategies, such as insurance coverage, diversification of crops, or adopting climate-smart agricultural practices.

To achieve all this goal Farm Beats, an end-to-end IoT platform is the solution. This system reduces loss, cut down costs and increase crop yields. It helps to collect seamless data from various sensors, cameras and drones This groundbreaking system integrates real-time sensor data and aerial spatial information captured by drones to create a highly accurate and immediate map of the farm. Before its use in precision agriculture, the system serves the purpose of monitoring temperature and humidity levels within storage spaces to prevent spoilage of produce. Additionally, farmers have strategically installed cameras at various locations, such as cow sheds and selling stations, to facilitate continuous monitoring (Deepak Vasisht *et al.*, 2017).

OVERCOMING CHALLENGES AND EMBRACING THE FUTURE

While biotechnology holds great potential for revolutionizing agriculture, it also faces several challenges that need to be addressed. Here are some of the key challenges faced by biotechnology in agriculture:

a. **Regulatory Frameworks:** Biotechnology products, particularly genetically modified organisms (GMOs), are subject to strict regulations in many countries. The lengthy and complex regulatory approval processes can delay the commercialization of biotech crops and increase the associated costs. Harmonizing and streamlining regulatory frameworks worldwide is essential to enable timely and efficient deployment of biotechnology innovations.
b. **Public Perception and Acceptance:** Biotechnology, especially GMOs, often faces public scepticism and concerns about their safety, environmental impacts, and ethical implications. Public perception and acceptance play a crucial role in shaping regulatory decisions, consumer choices, and market opportunities for biotech products. Engaging in effective communication and education about the benefits and safety of biotechnology is necessary to bridge the gap between scientific advancements and public perception.
c. **Intellectual Property Rights:** Protecting intellectual property rights (IPR) is a critical aspect of biotechnology research and development. However, IPR issues, such as patents and licensing, can be complex and can limit access to biotech innovations, especially for small-scale farmers in

developing countries. Balancing IPR protection with fair access and benefit-sharing mechanisms is important to ensure broad access to biotech solutions, particularly for resource-poor farmers.

d. **Biosafety Concerns:** Addressing biosafety concerns associated with biotech crops is essential to mitigate potential risks to the environment and human health. Proper risk assessments, monitoring, and compliance with biosafety protocols are necessary to ensure the safe use and deployment of biotechnology products. Continued research and transparency in assessing the long-term effects of biotech crops are crucial for building public confidence.
e. **Resistance and Evolution of Pests:** Continuous and widespread use of certain biotech traits, such as insect resistance, can lead to the evolution of resistant pest populations. This poses a challenge in maintaining the effectiveness of biotech solutions and necessitates the development of integrated pest management strategies to combat resistant pests. Rotation of traits, refuge requirements, and proactive monitoring are essential to mitigate resistance issues.
f. **Access and Affordability:** Biotechnology advancements may be inaccessible or unaffordable for small-scale farmers, particularly in developing countries. High costs associated with research, development, regulatory compliance, and licensing can limit the availability and affordability of biotech solutions. Promoting equitable access, technology transfer, and capacity building in developing regions can help ensure that the benefits of biotechnology reach those who need them the most.
g. **Ethical and Social Considerations:** Biotechnology raises ethical and social considerations, such as the potential impact on biodiversity, traditional farming practices, and socio-economic disparities. It is crucial to engage in open dialogue and involve diverse stakeholders, including farmers, consumers, scientists, and policymakers, to address these concerns and ensure that biotech solutions are and deployed in a responsible and sustainable manner.
h. **Unforeseen Environmental Impacts:** While biotechnology has shown significant benefits, the long-term and indirect environmental impacts of biotech crops are still being studied. Potential effects on non-target organisms, biodiversity, soil health, and ecosystem functioning require continued monitoring and research to ensure that the benefits outweigh any potential negative consequences.

CONCLUSION

From the laboratory to the field, the biotech revolution in agriculture has reshaped the way we grow, protect, and harvest our food. With genetic engineering, precision breeding, and crop protection technologies at its core, biotechnology has proven to be an unstoppable force in addressing global challenges. Embracing the potential of biotech while addressing concerns through responsible practices will pave the way for a sustainable and resilient agricultural future, ensuring food security for generations to come.

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Chapter
19

AN OVERVIEW ABOUT MICROGREENS-BENEFICIAL CHARACTERISTICS AND THEIR NUTRITIONAL FACTS

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ABSTRACT

Microgreens are special and healthy vegetable greens and they are easy to grow as indoor plant and it saves water usage, reduces pesticides and fertilizers utilization compare to outdoor plants. Compare to mature greens, microgreens contain high quatity of nutritional ingredients such as phenolics, iron, calcium, minerals, ascorbic acid, vitamin E and proteins. They are harvested within few days after germination with fully developed cotyledon. Microgreens are considered as healthy medicine which help to reduce chronic disease such as thalassemia, hemolytic anaemia. Microgreens are added in salad, soup, sandwich and main dishes as well, because of its beneficial characteristics and nutritional facts and reduce many life time diseases too. They produce bright colours and enhance the texture of the food. Hence, this review is focused on benefits of microgreens, various kinds of microgreens, reasons for choosing different kinds of microgreens and their nutrional value.

KEYWORDS: Microgreens, fucntional food, nutritional content, germinated seeds.

INTRODUCTION

This review is based on microgreens which is easy to grow at home and even it can be cultivated in soiless environment which reduce the water usage compare to outdoor plants. Microgreens are also known as 'vegetable confetti' the word confetti originated from italy meaning 'candied'. Fuente de la et al, . 2019 stated that microgreens are new food for 21St century. They are considered as health food because of the presence of favourable amount of micro nutrient and bio active compounds in it. They are obtained from seeds of various species which are young and harvested within few days after germinationfrom fully developed cotyledon(Paradise *et al.*, 2018).

Currently small scale vegetables have become popular for household food preparations and created a higher remarks in the instant market and *dietary supplement markets*. Sprouts and microgreens can be produced feasbily and cost effectively due to simple requriments for cultivating and easy to supply as a product in market. Their seeds are edible to eat and which shows more interest among diet conscious people (Galieni *et al.*, 2020).

Basically there are two types of cultivation methods for microgreen such as conventional and hydroponic methods. In hydroponic method, mineral nutrient solution has been used as aqueous solvent withoutusage of soil for the cultivation of microgreens which reduces the need of fertilizer, pesticides and high levels of water consuption. Many vegetables, herbacious plants, flavourable herbs and wide species can be used as microgreens. It takes 7 to 10 days to grow and it is recently used as a cut vegetable (Berba and Uchanski, 2012).

Some microgreens are easily germinated and grow rapidly such as Cabbage, Beetroot, Amaranthus and Mustard. Until now more than 80-100 microgreens have been produced commercially. It is grown in soil or soil like materials. Hydroponics methods are the suitable method for cultivation of microgreens. It composed of ascorbic acid, vitamin E, vitamin K, beta carotene that are five times more than mature plants (Rohini *et al.,* 2016).

In many countries, microgreens can be incorporated into a variety of dishes, including sandwiches, wraps and salads. It may also be blended into smoothies or juiced. Wheatgrass juice is a popular example of a juiced micro green. Another option is to use them as garnishes on pizzas, soups, omelets, curries and other warm dishes. Arugula mircogreens are used as garnishes on pizzas in America, sunflower microgreens are used in pesto dish in Italy, Mustard microgreens are used in sushi in Japan, bean microgreens are used in pho dish which is a type of vietnamese soup, fenugreek microgreens and mustard microgreens are used in very popular dish called "Butter chicken"in India (https://grocycle. com/best-microgreens-recipes/).

A microgreens market in India is both profitable and practical to start up. Now a days many business men and investors are investing their money for this profitable business because it requires less space and cost effective. Also due to lack of protein many childrens are suffering from many disorders these microgreens help them to increase their protein content level and boost their immunity (https://startuptalky. com/micro-green-business-india/).

BENEFITS OF MICROGREENS

Micro greens play an important role in promoting wellness in the diet because they provide a high level of protein. Teng *et al.* (2021) stated that microgreens are considered as good sources of nutritional and bioactive compounds and have the ability to prevent chronic diseases and malnutrition.

The mineral content was comparable to that of hydroponic micro greens and the low potassium levels allowed them to provide dietary advice to patients with impaired kidney function (Fuente. *et al.,* 2019). Micro greens can be a good alternative to high calorie food for various disorders that are common at high altitude (Narendra Singh *et al.,* 2019). Enssle, Nicole, 2020stated that micro greens are simple to cultivate, grown with the minimal resources and have a short growing period.

Micro greens play imperative role in lowering the incidence of some chronic disease such as cancer, cardiovascular diseases, skin diseases and age-related eye diseases in clinical conditions such as thalassemia and hemolytic anaemia. (Niroula *et al.,* 2019). Different cultivation techniques can manage the metabolic processes of microgreens, which include manipulating the properties of light derived from light-emitting diodes (Giedra Samuoliene, 2019). Microgreens have been used to enhance the display of gastronomic contentment for several decades. (Daniel Czelatdko, 2019)

It is not only called as microgreens but also known as micro herbs that are part of the super food craze, but they are still high in nutritional value (Christine Brown -Paul, 2015). The nutritional value of microgreens could be improved by biofortification, which increase micronutrients levels during plant development (Martina Puccinelli *et al.,* 2019).

Microgreens are different from sprouts. They contain more carotenoids, chlorophyll, organic acid and sugar which shows greater anti- diabetic and anticholinergic activity (AnetaWojdylo *et al.,* 2020). Microgreens contain high level of antioxidants like polyphenols which can reduce the risk of heart disease. Huang *et al.* (2016) and Tangney and Rasmussen (2013) stated through animal studies that microgreens have the ability to lower the triglyceride and "bad" LDL cholesterol.

VARIOUS KINDS OF MICROGREENS

Different kinds of microgreens have been cultivated in many countries they are

S. No	Family	Examples
1.	Brassicaceae Family	Broccoli, Cauliflower, Watercress, Cabbage, arugula and radish
2.	Asteraceae Family	Endive, lettuce, radicchio and chicory
3.	Apiaceae Family	Carrot, dill, celery and fennel
4.	Amaryllidaceae family	Onion, leek and garlic
5.	Amaranthaceae Family	Quinoa, swiss chard, amaranth, spinach and beet
6.	Cucurbitaceae Family	Cucumber, squash and melon

Some of the cereals and legumes are also grown in to micro greens such as rice, wheat, corns and oats and chickpeas, lentils and beans respectively (Shashank Sharma *et al.,* 2020). Xiaoyan Zhang *et al.,* (2019) investigated on soya microgreens in which transcriptional changes in genes of microgreens showed high level of antioxidant capacity, phenolic compounds and that regulate the phenolic biosynthesis.

J. Hortic, CF Weber (2016) compared the soilless method and vermicompost method for cultivation of microgreens such as lettuce and cabbage and concluded that the soilless method is very comfortable method for growing microgreens and he examined various nutrients such as (P, K, S, Ca, Mg, Mn, Cu, Zn, Fe, Na).

Singh *et al.* (2020) reported that Fagopyrum sp. Contains a lot of essential nutrients, therapeutics, bioactive compounds and nutraceuticals which help the plants to withstand from environmental stress.

Amaranth, Coriander, Cress, green basil, Komatsuna, Mibuna, Mizuna, Pak choi, Purple basil, Pureleine, Swiss chard and tatsoi microgreens have been cultivated in whichswiss chard and coriander have high levels of antioxidants (Francesco Caraciolo *et al.,* 2020).

Broccoli (*Brassica oleracea* L var italica Plenck) green curly kale (*Brassica oleracea* var, sabellica L), red mustard (*Brassica juncea* L (zern) and radish (*Raphanus sativus* L.) hydroponic microgreens have been cultivated. Most of these microgreens composed of macronutrients and oilgoelements like iron and zinc and contain large amount of carotenoids. Radish and mustard contains large amount of minerals. When compare to mature vegetables, broccoli microgreen contains higher level of minerals (Fuente *et al.,* 2019).

Massimiliano Renna *et al.* (2020) Analysed the Protein, dietary fiber, β-carotene, α-tocopherol and mineral elements (Ca, K, Mg, Fe, Zn, Cu, Mn, and Na) and the results of the comparison indicated that micro cauliflower has higher nutrient quality compare to micro broccoli raab and micro broccoli.

Berba *et al.* (2012) Analysed about the respiration rates and shelf life of arugula micro green (*Eruca saliva*). Some of the microgreens like Dill, carrot, chicory , beet, onion are rich in vitamins and carotenoids.

REASONS FOR CHOOSING THESE MICROGREENS

There are many varieties of microgreens are available but some of them have high nutritive value which can be harvested easily within few days like green gram or mung beans, pearl millet and finger millet. These microgreens are easy to digest and especially they are low in calories. It adds'zing' (Energy) to the food.

GREEN GRAM

Green gram or Mung beans is the third most popular legumes grown and consumed in india. Green gram constitutes good source of carbohydrates, proteins (14. 6-33. 0g/100g) and minerals and its protein quality is better than other legumes. It has higher amount of protein and free from flatulence causing factor because of this reason green gram seeds are used for feeding babies. It contain higher amount of lysine compare to other legume seeds. The mung bean seeds are consumed as cooked beans, dhals, sprouts, microgreens, flour and used in various recipies (Adsule *et al.,* 2009, Zodape *et al.,* 2010).

It is cultivated because of its short span and good performance under adverse climatic conditions such as heat, drought and salinity. It is widely used as microgreens because of its nutritional value and health benefits (Rani *et al.,* 2018).

Green gram sprouts contains iron, folate, carotenoids and other bioactive compounds. One cup of green gram dal has 15. 5 grams of fiber which meets 70% of daily recommendation. It lowers the symptoms of constipation, diverticulosis and reduces cholesterol level and reduces the risk of heart disease and blood pressure level. Sprouted green grams has low calories, high amount of amino acids and antioxidants (Shanka *et al.,* 2020).

PEARL MILLET

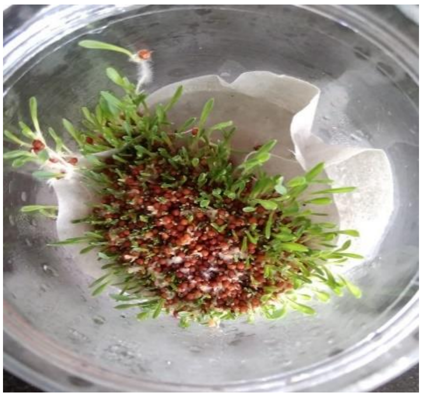
Pearl millet is a warm season grain can be cultivated in tropical environments. It is also suitable for cultivating under sandy, infertile soil and droughty environments too. Pearl millet grains have high protein and amino acid content, high level of iron, zinc and insoluble dietary fiber. It is also used as animal and poultry feed (Khairwal, *et al.,* 2007). It has high grain and fodder yield quality, greater water use efficiency and tolerance to heat are some of the reasons for cultivating pearl millet in summer season (Mula *et al.,* 2009).

Pearl millet contains good source of fat, vitamins and carbohydrates. While comparing to other crops it is nutritionally better and it has higher levels of iron, zinc, calcium, lipids and proteins. It is consumed as unleavened bread(bread without raising agent like yeast), porridge, gruel and dessert.

It is a stapel cereal of the arid and semi arid regions. As microgreens, pearl millet can be soaked and harvested within 7 days.

Pearl millet has the capacity for rapid growth and development under high temperature condition. Phenolic extract of pearl millet has a high range of anti-carcinogenic effect. It has high amount of fiber so its consumption reduces the risk of coronary heart disease. Pearl millet is very significant food for the patients with celiac disease because it is free from gluten (Jukanti *et al.,* 2016).

FINGER MILLET



Finger millet is a major food crop of semi-arid tropic areas. It is ranked fourth in the world among millet crop. Nutritionally, it is consumed as porridge in several countries but in asia it is used to make bread, roti . Because of its rich nutritional content it is used as weaning food for pregnant women and children. Finger millet seeds can be stored for 5 years because of low vulnerability to insect damage. It is drought tolerant, disease tolerant, weed tolerant (Thilakarathna and Raizada, 2017). Finger millet is rich in calcium, fiber, protein and minerals.

It has several health properties such as anti-diabetic, anti-inflammatory, anti-tumorogenic, antimicrobial (Dinesh Chandra, *et al.,* 2017). It is nutritionally important in comparison with rice, wheat and maize as it contains high level of iron, calcium, manganese and methionine (Bhim nath adhikari *et al.,* 2018). As microgreens finger millet can be soaked and harvested within 7 to 9 days. Finger millet has thirty times calcium more than rice. Millets has the ability to fight with hunger, malnutrition etc. (Sakamma *et al.*, 2017).

It is one of the least allergic and digestable grains. It is gluten free and very good option for people with celiac disease (Jayawardana *et al.,* 2019). It is often refered to as "crop for the poor" or famine food because it is consumed in many devoloping countries. It also has two essential Poly unsaturated fatty acids (PUFA), Linolenic acid and alpha linolenic acid (Glew *et al.,* 2008). Supplementing the finger millet to the children increases the hemoglobin level. It places a very significant role in losing weight for bone health, lowering blood cholesterol and anaemia.

NUTRIONAL VALUE OF SOME SEEDS

RAGI –"FINGER MILLET"

In India finger millet (*Eleusine coracana* L.) is also known as ragi contains rich source ofvarious phytochemicalsincluding phenolics, tannic acid, anthocyanins, phytosterols and policosanols and it is therefore used in various applications in food. Ragi contains higher concentration of protein content and and amylose (Himadari Mahajan and mahesh Gupta 2015). It is also known as ancient millet in India. Ragi contains highest level of calcium and potassium. While comparing white rice, ragi contains higher amount dietary fibre, minerals and sulfur containing amino acids (Amir Gul *et al.*, 2016).

It is a functional food because presence of functional component like body healing, bioactive components, antioxidants and dietary fiber. Ragi grains are easily digestible highly nutritious, and can be cooked and even it is used to make cakes. Sprouted ragi grains are suggested for infants and elder people because it is easily digesting food (Shobana, *et al.*, 2013).

Ragi contains 6% - 8% protein, minerals 2% -2. 25%, starch 65% - 75%, 1% -1. 7% fats and dietary fiber 18% to 20 different types of Proteins. Phenolic compounds, Minerals and dietary fibre are rich in seed coat of ragi. Amino acids composition such as Lysine, tryptophan, methionine, threonine leucine and isoleucine are present in it. Finger millet contains lipids like triglycerides which reduces the duodenal ulcer. It also contains fatty acids like oleic acid, linoleic acid, palmitic acids. Ragi contains higher amount of carbohydrates like free sugar, starch, non-starchy polysaccharides and dietary fiber. Compare to brown rice this finger millet contains higher amount of dietary fiber (Amir Gul *et al.,* 2016)

FENUGREEK

Fenugreek comes under fabaceae familywhich is a leguminous crop used as a spice and herb. Fenugreek 's native from Iran to northern India but now grown in almost, most of the places in the world (Olaiya and Olugboyega, 2014). It is one of the oldest and traditional medicinal plants which is also known as " an old world"crop for new world (Kralj *et al.,* 2020).

Fenugreek contains bitter taste because of presence of alkaloids and oil component which are non toxic and can consume in food. It contain a lot of components like lecithin and choline which helps to dissolve fatty substance and cholesterol. It also contains minerals, B-Complex, iron, phosphate, para benzoic acid, vitamin a and vitamin D. Higher content of fibre in fenugreek helps to enhance the strength for glucose tolerance. It contains saponins, hemicelluoses, mucilage, tannis and pectin which is responsilbe for decreasing the level of low density cholesterol in blood.

Fenugreek chemical constituents made it valuable as food and medicine and is also unique crop. The fenugreek seeds are rich in dietary fiber and play a major role in digestive tract and so lowers the absorption of glucose in intestine that by controlling the blood sugar level. Fenugreek is highly nutritious and play a significant role in human health and human can consume the fenugreek in many ways either directly or by adding it in dishes or in powder form.

Fenugreek is the source of macronutrient and micronutrient. Sotolon is the major chemicals which is responsible for fenugreek's distinctive sweet and smell. Fenugreek also contains volatile oil and fixed oil in lesser amount. Fenugreek endosperm is rich in protein like globulin, Histidine, albumin and lecithin. Fenugreek promotes higehr amount of aminoacids like 4-hydroxyisoleucine which has high potential for insulin stimulating activity. This 4-hydroxyleucine lower the absorption of glucose and also helps in bowel movement. It is also cure mouth ulcer and reduce menstrual pain.

Fenugreek has nutritional properties such as anti-Diabetic, anti-oxidants, anti-neoplastic, gastroprotective, hepatoprotective, hypercholestrolemic and hypoglycemic and contains high amount of phytochemicals. The fenugreeks used as fresh leavesas sprouts and microgreens in India (Olaiya and Olugboyega, 2014).

PEARL MILLETS

Pearl millet belongs to Paniceae of family Poaceae. In Africa and Asia, this millet is very important crop. Pearl millet believed to be domesticated from 4000. From eastern Africa only pearl millet has been cultivated in India.

Pearl millet contains higher amount of iron which helps to increase haemoglobin in anaemic patients. It has higher content of fiber which acts as anticancerous agent. It also lowers the content of sugar in diabetic patients. It also lowers the low density cholesterol. Pearl millet also contains large amount of flavonoids, phenolics Omega 3 fatty acids which helps in the development of bones.

Pearl millet is also recommended for stomach ulcers because it reduces acidity and prevents ulcers. In pearl millet because of lignin and phytonutrients helps in heart health and act as strong antioxidants. It prevents heart disease because of magnesium which controls blood pressure, and relieves heart stress. Also because of magnesium respiratory problems are also reduced.

It is also helped in reducing the migraine attacks. It is also helping in reducing the body weight. Consumption of Pearl millet reduces the hunger for longer duration. Pearl millet contain higher amount of fibre content which helps in preventing the gall stones because insoluble content in this millet which reduces the excessive bile production. Pearl millet also acts as an anti-allergic property. It also contains Vitamin, K, E, Thiamine, Riboflavin, Minerals, calcium, copper, selenium and sodium (Shweta Malik, 2015).

GREEN GRAM

Green gram contains more than 50 percentages of carbohydrates. Green gram contains more fibre content which is easy to digestible. Green gram contains mineral content in ascending order such as potassium>phosphorus>magnesium. Green gram sprouts contain iron, folate, carotenoids and other bioactive compounds. Green gram is rich in magnesium, sodium and calcium (Bhatty *et al.,* 2000; Mubarak, 2005 and Agugo *et al.,* 2009).

NUTRITIONAL CHANGES IN GERMINATED GREEN GRAM, PEARL MILLET AND FINGER MILLET

The nutritional content of legumes changes as a result of techniques like soaking, germinating and roasting. Many legumes are consumed as sprouts it improves eating quality along with nutritional quality by not only reducing the antinutrient factors but also increasing bioavailability of protein etc. (Mbithi-Mwikya *et al.,* 2000).

GREEN GRAM

When we compare the moisture content of raw green gram and germinated green gram it shows increase in those values. The increase in moisture content is due to the absorption of water by legumes. The green gram absorbs water between the period of raw to soaking.

The significant increase in protein content were observed in green gram. The increase is due to extensive breakdown of seed storage compounds and synthesis of structural proteins and other cell components that takes place during germination. Fat content is decreased in green gram with increase in germination time.

The decrease in fat is due to depletion of stored fat as a result of catabolic activity of the seeds during germination. Fiber content is increased in green gram. This increase is due to the synthesis of cell wall material like cellulose and hemicelluloses to support the shoots and roots during germination. In green gram, the carbohydrate content is increased due to the increase in other nutrients like protein, moisture, fat. Iron content is increased (Deepika sharma, 2018).

FINGER MILLET

The germinated finger millet shows improved nutritive quality. Long germination period of finger millet shows some loss in dry matter. During the period of germination, finger millet shows decrease in starch content, sugar content is increased during this period. There was a slight increase in protein content. The increase is due to the dry matter loss, particularly carbohydrates, through respiration, calcium and iron content is also increased (Mbithi-Mwikya *et al.*, 2000).

PEARL MILLET

Protein content of pearl millet is increased during germination. Fiber content is gradually increased. Fat content is decreased during the time of germination (Obadina *et al.*, 2017).

CONCLUSION

This review describes about the various kinds of microgreens which provided large source of bioactive compounds such as carbohydrates, proteins, vitamins minerals etc.)which can ve cultivated in small area the individual through hydroponic method. Microgreens are good suppplement for diet as they contain various range of nutrients which is easy to producr and consume by the individual without doing much efforts. This review paper concluses that microgreens are important to our current generation because of life style changes and reduce many disease and disorders.

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Chapter 20

BIOCHEMISTRY OF MUSHROOMS: ITS NUTRACEUTICAL AND MEDICINAL IMPORTANCE

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ABSTRACT

Mushroom is the general term used for a fleshy fruiting body of some fungi arising from the group of mycelium buried in the substratum. Most of them are from the sub division of Basidiomycotina and few from Ascomycotina fungi. Generally they are distinguished by a stem, fleshy rounded cap, and gills underneath the cap. Many types of mushrooms are edible and rich source of all needed material for our life. There are about 50,000 known species of fungi and about 10,000 are considered as edible ones. Of which, about 180 mushrooms can be tried for artificial cultivation and 70 are widely accepted as food. Mushrooms are being used as food and medicine since time immemorial. Traditional and folk medicine practitioners are using mushrooms for their healing and cleansing properties. These have been considered as the Delicacy, in the nutrition point of view mushrooms are placed between meat and vegetables and also called as vegetable meat. All varieties of mushrooms are low in calories and fat, and contain modest amounts of fiber and various nutrients. Mushrooms constitute both a nutritionally functional food as well as a source of physiologically advantageous medicine. Mushroom consumption is increasing rapidly worldwide due to their rich source of bioactive compounds such as functional protein, vitamins, minerals and dietary fibers etc due to that considering it as precious, and functional food ingredient. We need to educate, make aware among the people to provide good health and about the rich source of require food for human growth for the growing population to reach SDGs.

KEYWORDS: Mushroom, Medicinal Importance, Neutraceutical, Bioactive.

INTRODUCTION

Mushrooms are a group of fungi, with fleshy, spore bearing fruiting body, typically produces above the ground of the soil or on its food source. Which absent Chlorophyll, it considered as saprophytes, hence it obtained their nutrition from metabolizing nonliving organic matter. There are about 50,000 known species of fungi and about 10,000 are considered as edible ones. of which, about 180 mushrooms can be tried for artificial cultivation and 70 are widely accepted as food. Worldwide accepted edible mushrooms are Button Mushroom *Agaricus bisporus, Straw Mushroom Volvariella volvacea, Oyster Mushroom Pleurotus ostreatus, Milky Mushrooms Calocybe indica*, Cremini Mushroom *Agaricus bisporus*, Shiitake *Mushroom Lentinula edodes, Portobello Mushroom Agaricus, Enokitake mushrooms Flammulina velutipes, Morel Mushrooms Morchella esculenta, Lentinula edodes*, Oyster Mushrooms-*Pleurotus ostreatus*, King Oyster Mushroom -*Pleurotus eryngii*, Lion's Mane Mushrooms *Hericium erinaceus*, Enoki Mushrooms -*Flammulina velutipes*, Porcini Mushrooms -*Boletus edulis*, Maitake *Grifola* *frondosa*, Matsutake Mushroom - *Tricholoma matsutake*, Reishi Mushroom - *Ganoderma lingzhi*, Giant Puffball *Calvatia gigantean*, Buna Shimeji Mushroom *Hypsizygus tessellates*, Pepeao Jaws Ear Mushroom *Auricularia auricula-judae*, Straw Mushroom - *Volvariella colvacea*, Chanterelle Mushrooms *Cantharellus cibarius* and Other important edible mushrooms are Calocybe, Coprinus, Boletus, Flammulina and Termitomyces etc. Not all mushrooms are edible, wild mushrooms with white gills or a ring around the stem are considered poisonous. Some other inedible mushrooms look like edible mushrooms, also are there i.e *Amanita phalloides* (Death Cap), *Amanita muscaria, Amanita virosa* (Distroying Angel), *Paxillus involutus, Tricholoma muscarium* etc (Figure-1).

Fig. 1: Most Widely Cultivating, Edible Mushrooms and Poisonous Mushrooms

BIOCHEMICAL CHARACTERISTICS OF MUSHROOMS

Mushrooms contain moisture 85–95%, Carbohydrates 35–70%, includes starches, pentoses, hexoses, disaccharides, amino sugars, sugar alcohols, and sugar acids. Glycogen -α-glucans.β-glucans, Protein 15–34.7 protein content ranges are from 17 g to 42 g per 100 g of dried fruit bodies, significant amino acids i.e leucine, aspartic acid, valine, glutamine, and glutamic acid are found, Lipids little fat (4–6%) without cholesterol, important fatty acids linoleic acid, oleic acid, and palmitic acid are included, minerals 6–10.9% mostly potassium, calcium, iron, manganese, magnesium, copper, selenium, zinc etc, nucleic acids 3–8%, and large amount of vitamins such as thiamine 1.4–2.2 mg, riboflavin 6.7–9.0 mg, niacin 60.6–73.3 mg, biotin, ascorbic acid 92–144 mg , pentatonic acid 21.1–33.3 mg, and folic acid 1.2–1.4 mg/100 g in dry weight. The fruiting body contains approximately 100 different bioactive compounds such as functional protein glucans, laccase, proteoglycan (ubiquinone-9, nebrodeolysin, and lycoprotein), proteoglycans, pleuran (β-1, 3-glucan with galactose, and mannose), pleurostrin (peptide), and phenolic compounds include phenolic acids, flavonoids, hydroxy cinnamic acids, hydroxybenzoic acids, lignans, tannins, stilbenes, oxidized polyphenols and dietary fibers. The fruiting bodies are high in antioxidants and anti-aging components like ergothioneine, phenolic compounds, and indole compounds like melatonin, serotonin, and selenium, and found 55 fragrance compounds in mycelium, namely, 27 esters, 9 ketones, 7 thiols, 5 alcohols, 4 terpenoids, 2 phenols, and 1 aldehyde, and also have ash, glycosides, volatile oils, tocopherols, flavonoids, carotenoids, folates, organic acids, etc.

Table 1: Nutrients content in Mushrooms

Nutrient	Average in 1 cup of mushrooms (100gr)
Protein (g)	3.0
Carbohydrate (g)	3.1, including 1.9 g of sugar
Energy (calories)	21.1
Calcium (mg)	2.9
Iron (mg)	0.5
Magnesium (mg)	8.6
Phosphorus (mg)	82.6
Potassium (mg)	305
Sodium (mg)	4.8
Zinc (mg)	0.5
Copper (mcg)	305
Selenium (mcg)	8.9
Vitamin C (mg)	2.0
Vitamin D (mg)	0.2
Folate (mcg DFE)	16.3
Choline (mg)	16.6
Niacin (mg)	3.5

Table 2: Nutritional Value of few most widely Cultivated and Edible Mushrooms

Mushroom	Carbohydrate	Protein	Fat	Fiber	Vit-D (IU/g)	Ash	Energy (Kcal)
Agaricus bisporous	46.19	33.38	3.10	20.80	985	5.80	489
Pleurotus sajor-caju	63.40	20.13	2.70	48.60	496	6.36	426
Pleurotus ostreatus	57.60	30.40	2.30	8.70	484	9.80	275
Volvarella volvaceae	54.80	37.60	2.60	5.60	463	1.20	306
Lentinula edodes	47.60	33.23	3.75	28.90	415	5.20	395
Calocybe indiaca	64.36	17.89	4.10	3.40	486	7.45	393
Auricularia auricula	82.80	4.30	8.30	20.10	438	4.60	358
Flammulina velutipes	73.10	17.50	1.90	3.60	316	7.40	374

Table 3: Medicinal value of few edible Mushrooms

Mushroom	Compounds	Medicinal properties
Agaricus bisporus	Gallic acid, protocatechuic acid, catechin, caffeic acid, ferulic acid and myricetin, Lectine	Antioxidant activity
		Immune system enhancer
		Anticancer
		Enhance Insulin Secretion
Pleurotus ostreatus	Lovastatin: inhibitor of 3-hydroxy-3-methylglutaryl coenzyme A reductase	Reduction of cholesterol
	Oyster mushroom concentrate	Anti-inflammatory activity
Pleurotus eryngii	Acidic glycosphingolipids	Antitumour activity; immune system enhancer; antibacterial activity
Lyophyllum shimeji	A novel fibrinolytic enzyme: α-chymotrypsin	Blood anticoagulant
Lentinula edodes	Polysaccharides, Eritadenine, Lentinan	Antioxidant, Anticancer, Lower Cholesterol
Auricularia auricula	Acidic Polysaccharides	Decrease Blood Glucose
Ganoderma lucidum	Ganoderic acid, Beta Glucan	Liver Protection, Augments immune System, Inhibit Cholesterol Synthesis, Antibiotic Properties
Ganoderma frandosa	Polysaccharides, Lectins	Increase Insulin secretion, decrease blood glucose
Crucibulum leave	A new salfredin-type metabolites (DSM 1653 and DSM 8519	Inhibition of the enzyme aldose reductase
Cordyceps sinensis	Cordycepin	Cure Lungs Infection, Hypoglycemic activity, Anti-depressant Activity, Cellular Health Properties
Phallus indusiatus	A β-D-glucan called T-5-N	Anti-inflammatory properties
		Antioxidant capability
Flammulina velutipes	Ergotheoneine, Proflamine	Antioxidant, Anti-Cancer activity
Hericium erinaceus	Glycoprotein HEG-5	Hemaglutinating activity
	Polysaccharides (HEPs)	Antibacterial activity against Helicobacter Pylori
	Glycoprotein HEG-5	Anticancer potential against human gastrointestinal cancers

Mushroom	Compounds	Medicinal properties
Hydnellum Peckii	(2,5-dihydroxy-3,6-bis (4-hydroxyphenyl)-1,4-benzoquinone)	Anticoagulant
		Antibacterial activity atromentin and leucomelone
Trametes versicolor	Polysaccharide -K	Decrease Immune system Depression

NUTRACEUTICAL, MEDICINAL IMPORTANCE OF MUSHROOMS

From the ancient times, mushrooms have been considered as a special category of Nutraceuticals. Mushrooms constitute both a nutritionally functional food as well as a source of physiologically advantageous medicine. In the Nutraceutical point of view mushrooms are recognized to have elevated levels of proteins, carbohydrates , fibers, microelements, indoles, polyphenols, carotenoids, tocopherols, high significant amino acids, low fat contents, polyunsaturated fatty acids and small amounts of saturated fatty acids are almost ideal for a nutrition program aimed to prevent hypercholesterolemia, cardiovascular diseases, reduction of total blood cholesterol, lipoprotein cholesterol and antioxidant activities, in the regulation of blood lipid levels and reduction of blood glucose levels also used as therapeutic foods to check diseases such as hyper-diabetes, hypertension, atherosclerosis and cancer mainly due to their chemical profile (Table-1 & 2).

Mushrooms are famous precious and considered functional food ingredients, recently mushroom consumption is increasing rapidly worldwide due to their rich source of bioactive compounds, functional protein, cholesterol-free and low in calories, excellent source of vitamins such as thiamine (vitamin-B1), riboflavin (B2), niacin, pantothenic acid, biotin, folic acid, vitamin C, D, A and K which are retained even after cooking. And high K: Na ratio, they are ideally suited for diabetic and hypertension patients.

The antioxidant content in mushrooms help in prevent lung, prostate, breast, and other types of cancer, choline help in muscle movement, learning, and memory, transmission of nerve impulses, reduce the risk of some types of cancer, Dietary fiber, Beta-glucans may help manage type 2 diabetes, reduce blood glucose, potassium can help regulate blood pressure, and this may decrease the risk of hypertension and cardiovascular disease. Mushrooms are rich in B vitamins help the body to get energy from food and form red blood cells. Mushrooms make a great replacement for meat because of their umami flavor.

Mushrooms are useful as complex carbohydrates strengthen the immune system, to increase the protein content in their diet helps lower cholesterol, Niacin can be another good supplement for vegetarians, Ergosterol performs the same function as cholesterol and Vitamin D precursor good Non Animal dietary source. as a powerhouse of minerals, **copper** help the body to absorb oxygen and create red blood cells, contain more selenium than any other form of produce, it acts as antioxidant to neutralize free radicals**,** **potassium** is an extremely important mineral that regulates blood pressure and keeps cells functioning properly. ergothioneine antioxidant for the protection against cardio vascular diseases, chronic inflammatory conditions, ultraviolet radiation damages, and neuronal injuries. Alkaloids like Cordycepin, Lectins, Lovastatin for various body functions.

Mushrooms inhibit the production of certain enzymes such as aromatase, which the body uses to make estrogen, it reduces the risk of breast cancer. Triterpenes inhibit histamine release and have anti-inflammatory properties. Vitamin H or Biotin is essential in the metabolism of carbohydrates and proteins; it strengthens our inner health by increasing immunity. Beta-glucans- improve insulin resistance and blood cholesterol levels, lowering the risk of obesity and providing an immunity boost, boosts the function of T-Cells. Choline, an important nutrient that helps with sleep, muscle movement, learning, and memory. Controls Blood Sugar, Reduces Blood Pressure Level, minerals like selenium, potassium, copper, iron, and phosphorus, are available in mushrooms protect against cancer, protect heart health- prevents plaque formation and also helps to reduce inflammation of the cells in the arteries, Immunomodulatory properties, Anti-inflammatory properties prevents Atherosclerosis, Mushrooms have more medicinal properties it help to control many human ailments include anti-oxidant, anti-inflammatory, anti-carcinogenic, anti-microbial, antibacterial, anti-fungal, anti-diabetic, anti-angiogenic, immunemodulatory, hepatoprotective, hypoglycemic, anti-viral, anti-tumor, anti-hypercholesterolemic, anti-hypertensive, protecting the liver, promoting general fitness, anti-asthmatic, anti-obesity, anti-atherosclerotic, and anti-ulcer, besides being used as functional foods. Renal and cardiotoxic proteins from Flummulia uelutipus and Volvariella volvacea, Auriicularia polytricha, Agaricus bisporus, and Lentinus edodes show hylipidemic effect it reduces cholesterol level in the blood. Hallucinogenic mushrooms use in the treatment of mental disorders, Polyporus officinalis is used to stop night sweating in tuberculosis, to cure chronic diseases of lungs, breast, gout, jaundice rheumatism etc. Mushrooms and their bioactive components can prevent CVDs, Neurodegenerative diseases (NDs) like Huntington's disease (HD), Alzheimer's disease (AD), and Parkinson's disease (PD), etc. (Table -3). Due to that fact Increased interest in consuming mushrooms to remedy and to treat numerous dangerous illnesses around the world.

CONCLUSION

Mushrooms are the fleshy fruiting body of some fungi arising from the group of mycelium, mushroom use as food and medicine since time immemorial. It is having the great Nutraceutical and medicinal properties. Nutracuetical point of view mushrooms are considered as vegetable meat. In recent days mushroom consumption as a food and to treat numerous illnesses around the world is rapidly increasing due to their Nutraceutical medicinal properties. Still there is a lack of knowledge of mushrooms consumption, there is a need of inculcate awareness about mushroom consumption, mycologists, scientists, mushroom growers need to do more awareness programmes, trainings in the cultivation, consumption perspective for the growing population to overcome food scarcity mushrooms are the best alternate food source.

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Chapter 21

ORGANIC FARMING: A SUSTAINABLE AGRICULTURAL APPROACH

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ABSTRACT

India is agriculture-based country and most of its economy depends on it. The populations mainly depend on the agricultural output for their daily demands. Traditionally since thousands of years, Indian farmers were depending on conventional systems of agriculture and have obtained the productivity. The Agricultural systems have improvised over centuries according to the needs and demands of the people.

KEYWORDS: Organic farming, sustainable agriculture, Economy, Indian farmers.

INTRODUCTION

India is agriculture-based country and most of its economy depends on it. The population mainly depends on the agricultural output for their daily demands. Traditionally since thousands of years, Indian farmers were depending on conventional systems of agriculture and have obtained the productivity. The Agricultural systems have improvised over centuries according to the needs and demands of the people.

Promoting the application of science and technology in agriculture is the foundation to improve the productivity, quality, efficiency and competitiveness of agriculture, contributing to the modernization of agriculture and rural areas, ensuring food security, social security and income enhancement for agricultural producers and traders. In 20th century modern agriculturists introduced new technologies and systems that created Revolution in Agriculture in India and abroad. Advances in technology and farming practices have helped farmers become much more productive, growing crops efficiently in areas most suitable for agricultural production (Kulkarni S. 2022).

After the initiation of green revolution during 1960's by Dr. M.S. Swaminathan, there were tremendous changes in the agricultural sector. There was more demand for imported improved seed varieties, fertilizers and technologies. It resulted in tremendous turnover in agricultural productivity and farmers willingly accepted the technology. But the exhaustive use of chemical fertilizers and hybrid technology over last 50-60 years started showing negative effects on land, health and environment including pollution. Thus there is an urgent need of alternative sustainable technology like Organic farming.

The concept of sustainable agriculture using organic farming methods has gained acceptance in India due to rapid degradation of natural resources, increase of production cost of conventional farming and deterioration of land (Gaur, 2010). The studies indicated Alternative technologies like Mycorrhiza and Organic Farming is a promising technology for sustainable agricultural development and has proved the potential for reclamation of soil types and plant growth from semiarid zones (Sangita Kulkarni, 2022). Many of the agricultural universities showed pioneer interest in concept of natural farming in India. Mr. Subhash Palekar (Padma shri–awardee) is famous as 'krishika rishi' and pioneered this concept.

The reports of prosperous Organic farming thriving in Indian Civilization is mentioned since ancient times, where the fertilizers and pesticides, were of Organic origin, obtained purely from plant and animal products. till the british ruled it. During the British regime, the study and literature of Organic farming was narrated by J.I. Rodale (USA). The eminent scholars like Lady Balfour (England) and Sir Albert Howard in India also contributed to the cause of organic farming.

Organic farming is novel agricultural system that improves crop productivity, provides healthy food, better nutrients in products, healthy soils, healthy plants, and healthy environment. It also repairs, maintains, and improves the soil structure and ecological balance. The farming system mainly depends on crop rotations, animal manures, green manures, use of crop residues, organic wastes, Biofertilizers, mechanical cultivation, mineral rocks and biological control to maintain soil productivity and to supply plant nutrients and to control insect, weeds and other pests. The organic farming methods can produce even higher yields than conventional methods. The organic is an 'agro ecological' farming system that offers many benefits like conserving ecosystem, sustainability of natural resources, preserve animal welfare, better agricultural output, It is a soil based farming system that helps in cultivating land and raising crops with healthy soil alive and use of various kind of organic wastes including crop, animal and farm waste, aquatic waste, etc., and Biofertilizers. The organic farming has helped in sustainable agricultural productivity through Environmental conservation and soil sustainability.

The organic farming includes many advantages like no expensive fertilizers, pesticides, or hybrid seeds, Environment-friendly, High demand for organic products, high returns on investments and nutritional food. This farming includes few limitations like Limited supply, limited production, slow growth and profit. This farming system excludes the use of synthetic fertilizers, pesticides, growth regulators, and genetically modified organisms and livestock food additives. Based on the utility, the Organic farming is divided as - Integrated and Pure. The integrated system includes integration of pest management and nutrients management to achieve ecological requirements and demands while the pure system includes use of natural plant and animal resources.

It helps in maintaining clean and rich environment and shows about 30 percent higher Floral and Faunal diversity in fields compared to conventional farming. The Covid-19 pandemic has changed the perception of organic food, showing the benefits of safe and healthy food that is nutritious to build a strong immune system. The food nutrition is more important than its security. Thus, the demands for the organic products have exponentially increased in last 2-3 years. The reports of Department of Agriculture indicate that the worldwide Organic Agriculture is practiced in 187 countries and 72.3 million hectares of agricultural land with at least 3 million farmers. The countries like Australia (35.69 m hectares) followed by Argentina (3.63 m hectares) and the Spain (2.35 m hectares) are more focused on natural Organic management. The popularity of the products has gained importance in recent years and all the organic areas worldwide has summed up to 107.4 million hectares (Organic World 2021).

Thus, with the increasing food demand and the food security, the scope of Organic farming is most suitable solution presently for sustainable agriculture. It will meet the demands of the society as healthy and nutritious food.

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Chapter 22

A REVIEW ON THE MEDICINAL AND PHARMACOLOGICAL PROPERTIES OF TRADITIONAL ETHNOMEDICINAL PLANT SONAPATHA, *OROXYLUM INDICUM*

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ABSTRACT

Oroxylum indicum, commonly known as Tutu and belong to Bignoniaceae family. It is used to treat several human ailments since ancient times. It is used to treat the various diseases such as; urticaria, jaundice, asthma, sore throat, laryngitis, hoarseness, gastralgia, diarrhea, dysentery, infantile, erythema measle, etc. It is also having potential to treat against SARS-CoV-2 (COVID-19) infection in humans. Studies also report that species having the various functional properties like; antioxidant, anti-inflammatory, anticancer, antimicrobial, anti-arthritic etc. In this review, it has been an attempt to explore the ethnobotany, phytochemistry and therapeutical potential of this medicinally important tree.

KEYWORDS: *Oroxylum indicum*, ethnobotany, phytochemistry, therapeutical, medicinal plant.

INTRODUCTION

ETHNOPHARMACOLOGICAL RELEVANCE

Oroxylum indicum (L.) Kurz has been used for centuries as a traditional medicine in India in ethnomedicinal systems for the prevention and treatment of several diseases, such as jaundice, arthritic and rheumatic problems, gastric ulcers, tumors, respiratory diseases, diabetes, and diarrhea and dysentery, among others. The present review provides scientific evidence supporting the therapeutic potency of the plant for ethnomedicinal uses and identifies gaps for future research to facilitate commercial exploitation.

Oroxylum indicum is a species of flowering plant belonging to the monotypic genus oroxylum and the family Bignoniaceae, and is commonly called Indian trumpet tree, Oroxylum, Indian Trumpet flower, broken bones, Indian caper, scythe tree or tree of Damocles. It can reach a height of 18 metres (59ft.). Various segments of the tree are used in traditional medicine, where it is known as Shyonaka or Sona patha.

TAXONOMY

Synonyms: *Bignonia indica, Spathodea indica, Calosanthes indica, Hippoxylon indica*

Kingdom: Plantae

Class: Magnoliophyta

Order: Lamiales

Family: Bignoniaceae

Genus: *Oroxylum*

Species: *indicum*

An extensively used medicinal tree of Ayurveda is Shyonak or *Oroxylum indicum*. It is one of the ten roots of famous Ayurvedic formulation 'Dashmula' (group of ten roots). This tree is mentioned in various Ayurvedic treatises. Sushrut and Charak prescribed Shyonak as antiseptic, astringent and prescribed for non-healing ulcers, female disorders and dysentery. Shyonak grows throughout India, chiefly in evergreen forest.

For the medicinal purpose its root, bark and gum are used. The roots of the tree are greyish-brown to light brown in color and tastes sweet. The main constituent of roots is Flavonoids and Tannins. The roots are astringent, bitter Tonic, stomachic, anodyne, anti-inflammatory and expectorant in action. They stimulate digestion, cure fever, cough and other respiratory disorders and are useful in diarrhea, dysentery, abdominal pain, thirst, vomiting, anorexia, rheumatism, worms, leprosy and other skin diseases, oedema and urogenital disorders. In Ayurveda, the roots are considered Tikta/Bitter, kashaya/Astringent (Rasa/taste), Laghu/Light, Ruksha/Dry (Guna/characteristic), Sheet/ Cool (Virya/Potency) and Katu/Pungent (Vipaka/Post Digestive Effect). In action, the roots are Dipana, Kapha-pitta-shamak and Grahi in nature. The roots are given to treat respiratory illness, low appetite, gout, abdominal diseases, ear diseases and swelling.

BOTANICAL DESCRIPTION

Oroxylum indicum is a small to medium sized deciduous tree light greyish brown, soft, spongy bark having corky lenticels, large pinnate, bipinnate or tripinnate ovate or elliptic leaves; lurid purple, fleshy, foetid flowers and large, flat, sword shaped capsules full of many flat and papery thin seeds with broad silvery wings. Leaves are large up to 1 – 5 m long, pinnate, bipinnate or tripinnate, leaflets are ovate or elliptic. They form enormous seed pods that hang down from bare branches. Those long fruits curve downward and resemble the wings of a large bird or dangling sickles or swords in the night. The fresh root bark is soft and juicy and creamish yellow to greyish in colour. The taste is sweet initially later becoming bitter. On drying, the bark shrinks, adheres closely to the wood and becomes faintly fissured. Flowers are many large, purple and fleshy with perfect five stamens. Fruits are Capsule, large, flat, sword shaped, up to 90 cm x 9 cm valves woody. Seeds are many flat, thin with broad silvery wing. The seeds are round with papery wings. Flowering starts in the cold season, from January to March and fruits are developed in April to July. The plant is also called as broken bones tree as when the long leaf and flower bearing stalks dry and fall from the tree, their accumulation beneath the tree resembles a pile of broken bones. The tree is a night bloomer and flowers are adapted to natural pollination by bats Microscopic Features Microscopic studies of the roots of Oroxylum.

The large leaf stalks wither and fall off the tree and collect near the base of the trunk, appearing to look like a pile of broken limb bones. The pinnate leaves are approximately 1 metre (3.3 ft) in length and comparably wide, borne on petioles or stalks up to 2 metres (6.6 ft) in length, making this the largest of all dicot tree leaves, which are quadripinnate (leaflets display four orders of branching).

Fig. 1: *Oroxylum indicum*: (a): whole tree; (b): leaves; (c): stem; (d): stem bark; (e): flower; (f): fruits, seeds

THERAPEUTIC USES

Root bark of sonapatha is an astringent, tonic, anti-diarrhoeal, diuretic, anodyne, and is used to cure dropsy. It is an ingredient of 'dashamoolarishta' of Ayurvedic medicine. Stem bark is anti-rheumatic. An infusion of bark powder is diaphoretic. Tender fruits have spas- molytic, carminative, and stomachic properties, while seeds are purgative.

MORPHOLOGICAL USES

Oroxylum indicum is a medium-sized, soft-wooded tree attaining a height of 10–16 m. Stem bark is dull brown in colour; leaves are broad, 60–120 cm in length and pinnately compound. Leaflets are ovate, wavy, and acuminate. Leaf fall occurs during winter season (January) each year. The tree is recognized by ternately bipinnate leaves.

IN MARRIAGE RITUALS

The plant is used by the Kirat, Sunuwar, Rai, Limbu, Yakha, Tamang in Nepal, the Thai in Thailand and the Lao in Laos.

In the Himalayas, people hang sculptures or garlands made from *O. indicum* (Skr. shyonaka) seeds from the roof of their homes in belief they provide protection.

THE CHEMICAL CONSTITUENTS

The chemical constituents of are always of an interest for the researcher. A number of secondary metabolites like flavonoids, glycosides, alkaloids, tannins, terpenoids, etc have been reported from various parts of the plant. Chemical constituents of different parts Part Chemical constituents The leaves Flavones, glycosides, baicalein, scutellarein anthraquinone and aloeemodin Root and stem Oroxylin A, baicalein, chrysin, pterocarpan, rhodioside, p-hydroxy phenyl ethanol's and cyclohexanols Root bark Bhrysin, baicalein, oroxylin A, dihydrobaicalein, β-sitosterol, iso-flavone and prunetin Stem bark Alkaloids, tannic acid, sitosterol and galactose Seeds Chrysin, baicalein, baicalein-7-O-glucoside, baicalein-7-O-diglucoside (Oroxylin B) Fruits Oroxylin A, chrysin and ursolic acid and aloe-emodin Ethnobotany.

The sword like fruit or a branch of the plant is used by the farmers to kill crabs in wet paddy fields. A paste made of the bark is applied to wounds of animals to kill maggots. In India fruits and flowers of the plant are consumed as a vegetable.

COLLECTION OF PLANT MATERIAL

The plant, *Oroxylum indicum*, was collected locally from the Organic farming field of gram Rohna which is under supervision of biodiversity board and gram vikas samiti near Itarsi Dist. Hoshangabad (India). This plant was used for its phytochemical analysis and antimicrobial test (Table 1). The fresh and tender leaves of selected plants were used for extraction.

PHYTOCHEMICAL TESTING

Table: 1 Phytochemicals testing of aqueous extract of *Oroxylum indicum*.

S.NO.	TEST	RESULT
1	Terpenoid	Negative
2	Tannin	Present
3	Alkaloids	Absent
4	Spooning	Absent
5	Proteins	Absent
6	Terpenes	Absent
7	Flavonoids	Present
8	Glycosides	Present
9	Polyphenol	Present

PHYTOCHEMISTRY

Various segments of *O. indicum*, including leaves, root bark, heartwood and seeds, contain diverse phytochemicals, such as prunetin, sitosterol, oroxylin-A, biochainin-A, ellagic acid, tetuin heartwood, and seeds, contain diverse phytochemicals such as prunetin, sitosterol, oroxindin, oroxylin- anthraquinone and emodin. Several of the compounds few under preliminary research to identify their potential biological properties. Flavonoids namely chrysin, oroxylin- A, scutellarin, baicalein. Leaves are also found to contain quercetin-3-oα-L-arabinopyranoside, 1-(2-hydroxyethyl) cyclohexane-1, 4-diol, apigenin.

Seeds: Seed of this plant are reported to contain ellagic acid.

Root bark: Root Bark is reported to contain chrysin, baicalein, biochanin-A and ellagic acid. The root bark has also been reported to contain two flavonoids 2, 5-dihydroxy-6, 7-dimethoxy flavone and 3, 7, 3′, 5′-tetramethoxy-4′- hydroxy flavone.

Stem bark: Stem Bark is found to contain ellagic acid22, chrysin, oroxylin-A, scutellarin, baicalein23,24, 5-hydroxy 8-methoxy 7-o-β-D-glucopyranuronosyl flavone25, stigmast-5-en-3- ol26, pratensol27, 3-(4-hydroxy phenyl) 2-propenoic acid28 and flavonoid 3,4′,5,7-tetrahydroxy-flavonol 29, 5-hydroxy 4′,7-dimethoxy flavone30, 7-o-methyl chrysin 31, dihydrooroxylin-A, methyl-3,4,5-trihydroxy-6-(5-hydroxy6-methoxy-4-oxo-2-phenyl chroman-7-yloxy)-tetrahydro2H-pyran-2-carboxylate, 5-hydroxyl- 7-methoxy-2- (2- methoxy -6-(3,4,5-trihydroxy-6-(hydroxy methyl) tetrahydro-2H-pyran-2-yoloxy)phenyl)-4H-chromen-4- one. Other chemical constituents contain prunetin and sitosterol from wood. Fruits are reported to contain oroxylin A, chrysin and ursolic acid33, aloe-emodin.

The seed oil: Seed Oil contains caprylic, lauric, myristic, palmitic, palmitoleic, stearic, oleic, and linoleic acids

ECOLOGY

Oroxylum indicum lives in relationship with the actinomycete Pseudonocardia oroxyli present in the soil surrounding the roots. Septobasidium bogoriense is a fungal species responsible for velvet blight in *O. indicum*.

PHARMACOLOGICAL REPORTS

ANTIBACTERIAL ACTIVITY

Oroxylum indicum is reported to possess antibacterial activity. The methanolic, ethyl acetate, and ethanolic extracts of stem bark of *Oroxylum indicum* were tested on three different species of gram-positive and gram-negative bacteria viz. *Bacillus subtills, E. coli*, and *Pseudomonas aeruginosa* of the extracts were found to possess remarkable antibacterial properties. The crude petroleum ether, methanolic and ethyl acetate extracts of root bark of *Oroxylum indicum* and the two compounds isolated from them. 2,5-dihydroxy 6.1- tetramethoxyflavon and been found to have moderate to good antimicrobial and antifungal activity. The results of the study justified the use of this plant in the management of microbial infection. The three fractions, hexane, CCL4 and

ANTI-INFLAMMATORY AND ANALGESIC ACTIVITIES

The 50 μg/mL of dichloromethane root extracts of Sonapatha resulted in 100% inhibition of leukocyte lipoxygenase activity indicating its anti-inflammatory potential. The aqueous leaf extract of Sonapatha has shown anti-inflammatory activity in carrageenan induced rat paw edema test where 300 mg/kg body weight (b. wt.) extract was found to be superior over 150 mg/kg b. wt. . A similar effect has been reported for the Sonapatha root and stem bark decoction in water that reduced the carrageenan-induced rat paw edema. The rats treated with aqueous root extract of Sonapatha at a dose of 100, 200 and 400 mg/kg b. wt. for seven or four days significantly inhibited the induction of dinitrobenzene sulfonic acid-induced colitis. The oral administration of 500 mg/kg b. wt. reduced acetic acid writhing, which was comparable to standard analgesic agent aminopyrine given at a dose of 50 mg/kg. The aqueous extract of Sonapatha has been reported to reduce mouse ear edema in an earlier study. The ethanol extract of Sonapatha (250 and 300 mg/kg b. wt.) was evaluated for its anti-inflammatory and analgesic activities and 300 mg/kg ethanol extract reduced mice ear and paw edema and also exerted analgesic effect to the maximum extent. The hydroalcoholic extract of Sonapatha stem bark extract exerted anti-inflammatory activity on carrageenan-induced rat paw edema. The Sonapatha extracted in methanol and given at a dose of 100, 200, and 400 mg/kg b. wt. has been reported to reduce carrageenan-induced rat paw edema depending on its dose. The histological evaluation of rat paw showed reduced cell infiltration and suppressed inflammation in a dose-dependent manner.

ANTI-ALLERGIC AND ANTIASTHMATIC EFFECT

Allergic rhinitis and asthma are linked and affect 40% of the world population. They reduce the quality of life and performance and their prevalence has been increasing in the population throughout the world. The studies on the antiallergic and antiasthmatic effect of *Oroxylum indicum* are scanty. The antiallergic and anti-asthmatic effects of oroxylin an extracted from Sonapatha have been studied in female Balb/c mice and cultured rat RBL2H3 mast cells. The rat RBL-2H3 mast cells sensitized with monoclonal anti-dinitrophenyl specific mouse IgE and then exposed to 0.1, 0.3, 1, 3, 10, and 30 μM oroxylin A reduced the antigen-induced degranulation in a concentration-dependent manner as indicated by the release of β-hexosaminidase. The maximum degranulation and β-hexosaminidase release were estimated at a concentration of 30 μM oroxylin A in RBL-2H3 mast cells. The female Balb/c mice were injected with 1 and 5 mg/ kg b. wt. oroxylin A intraperitoneally 30 before OVA administration to induce asthma inhibited the accumulation of eosinophils in bronchoalveolar lavage fluid of mice by 51% and 84%, respectively. The histologic observa- Sinusitis 2021, 5 79 tions of mice lungs revealed the accumulation of eosinophils around bronchioles whereas oroxylin an administration alleviated the eosinophils around bronchioles depending on its dose. The oroxylin an administration also reduced the OVA-induced mucin production in the mice lungs. The study on various cytokine expression revealed that oroxylin A suppressed the expression of IL-4, IL-5, and IL-13, INF-γ and IL-2 in the lungs of OVA administered mice, which may be responsible for its antiallergic and antiasthmatic activities in Balb/c mice.

IMMUNOSTIMULANT ACTIVITY

n-Butanol extract of root bark of *O. indicum* (100 mg/kg, once daily for 22 days) was studied for immunomodulatory activity in rats using measures of immune responses to sheep red blood cells (SRBC haemagglutinating antibody [HA] titer) and delayed-type hypersensitivity (DTH) reactions. In response to SRBC, treatment with the n -butanol fraction caused a significant rise in circulating HA titers during secondary antibody responses, indicating a potentiation of certain aspects of the humoral response. The treatment also resulted in a significant rise in paw edema formation, indicating increased host DTH response. Histopathologic analysis of lymphoid tissues in the treatment group showed an increase in cellularity, e.g., T-lymphocytes and sinusoids. In contrast, dexamethasone treatment caused significant reduction in the HA titer, DTH responses, and antioxidant activity. In a triple antigen-mediated immunological edema model, the extent of edema raised in drug-treated rats was greater compared to that in control rats, thus confirming enhanced DTH reactions in response to the drug treatment. Activity of the *O. indicum* might be attributed to its ability to enhance specific immune response (both humoral and cell-mediated).

NEPHROPROTECTIVE ACTIVITY

Root decoction and leaves of *Oroxylum indicum* are widely used as prophylaxis for kidney disorders and to remove kidney stones in Indian system of medicine79. The ethanolic extract of roots of *Oroxylum indicum* has shown protective effect against cisplatin-induced renal injury in Wistar male albino rats. nephrotoxicity was induced by cisplatin (6 mg/kg bw i.p.) as evidenced by significant increase in BUN, serum creatinine, urinary total proteins, LPO levels and decreased creatinine clearance level. On administration of ethanolic extract at two dose levels 200 and 400 mg/kg BW for 3 days starting one hour prior to cisplatin administration significantly restored all the parameters towards normal. Histological studies also substantiated the results8. The nephroprotective activity of *Oroxylum indicum* has also been evaluated in experimental rats. It has been considered as a great discovery that several flavonoids have been found to possess nephroprotective activity. In an experiment, chrysin isolated from roots of *Oroxylum indicum* was evaluated for protective activity against cisplatin-induced nephrotoxicity. Chrysin at a dose level of 40 mg/kg BW protected the kidney damage from nephrotoxic cisplatin in experimental rats. Animals which received chrysin reversed all the effects induced by cisplatin81. Antihyperlipidemic Activity The antihyperlipidemic activity of Oro

CONCLUSION

Thus, the plant is highly placed drug in the Ayurvedic medicine. It is one of the most versatile plants having a wide spectrum of medicinal activities. This medicinal plant is the unique source of various types of compounds having diverse chemical structure and nature. Active constituents of the plants are responsible for these activities. Since the plant is most useful, there is tremendous

SCOPE FOR THE RESEARCH

This review is based on available information on traditional uses and phytochemical, pharmacological, data for *Oroxylum indicum* that was collected from electronic (SciFinder, PubMed, Science Direct, and ACS, among others) and library searches.

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Chapter 23

SEED CERTIFICATION: ITS IMPORTANCE IN FOOD SECURITY AND SUSTAINABLE AGRICULTURE GROWTH

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ABSTRACT

Seed is a basic agricultural input and it is an embryo, embedded in the food storage tissue. Seed Certification is a legally sanctioned system for quality control of seed multiplication and production for the Identification of new superior varieties, provision of supply of quality seeds by careful maintenance, designed to ensure physical and genetic purity, freedom from weed seeds and diseases with good germination ability of the certified seed. Certification of Seed shall be completed in six phases as follows Receipt and scrutiny of application, Verification of Seed Source, Field Inspection, Post harvest Supervision, Seed Sampling and Analysis, Label, tag, grant of Certification. The purpose of Seed Certification is to maintain high quality seeds and propagating materials, to ensure genetic purity, identity and make available to public, through Certification. The challenges confronting seed sector are now more than even before due to demand of quality seed of promising varieties to ensure food security. To reach the sustainable agriculture growth and to end hunger, provide food security for the future generations, a good quality seed is the most basic and essential input.

KEYWORDS: Seed Certification, Sustainable agriculture, Food Security.

INTRODUCTION

Seed is a matured ovule which consists of an embryonic plant with storage of food and surrounded by a protective seed coat. It plays a vital role in agriculture and acts as a carrier of the genetic potential of varieties. Seeds are food for mankind, animals, and other living beings (Fig. 1). Globally 95% of the total food comes from the seed. About 250 species of seeds are used as food for human and animal beings. Majorly six species of seeds that are used for human consumption are Rice, Wheat, Berley, Oat, Maize, Rye etc. Seed is the store house of Carbohydrate, Starch, Hemicellulose, Sugar, Fats and oils, Protein, Mineral and Vitamin etc. Seeds are the basic commodity of agriculture, Seeds are the vehicle of life or means of propagation, used for medicinal purposes, supplies raw materials to industry. Seeds protect and sustain life and seeds are the national asset and may be compared with a country’s currency.

Investing in good quality seeds is a critical step in achieving a sustainable productive harvest, good quality seeds have high germination rates, which means more of your seeds will grow into strong, healthy plants. This can lead to higher yields and improved crop quality while reducing the need for chemical fertilizers and pesticides.

Seed Certification is a legally sanctioned system for quality control of seed multiplication and production for the Identification of new superior varieties, provision of supply of quality seeds by careful maintenance, designed to ensure physical and genetic purity, freedom from weed seeds and diseases with good germination ability and viability of the certified seed, it is the starting point to a successful crop as well as an important risk management tool.

The challenges confronting seed sector are now more than even before due to demand of quality seed of promising varieties to ensure food security. Every cultivar should able to access healthy seeds which are genetically pure, with high seed vigour and good germination percentage, timely availability of good quality seeds at reasonable price ensures good yield and profit to the farmers and to achieve the sustainable growth in Agriculture.

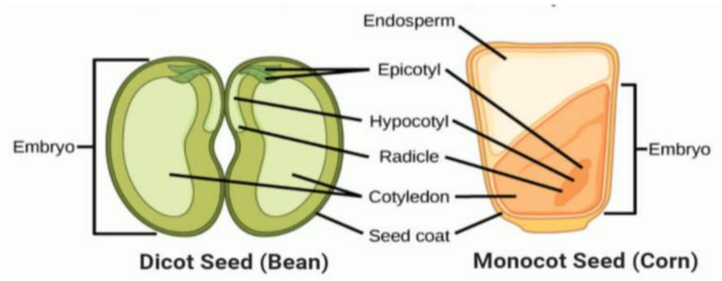

Fig. 1: Structure of Seed (Dicot & Monocot)

SEED CERTIFICATION

Seed is the most important and vital input for agricultural production. It is the most efficient means of increasing agricultural production. The direct contribution of quality seed alone to the total production is about 15-20% depending upon the crop and it can be further raised up to 45% with efficient management of other inputs.

The seed certification concept grew out of the increased concern for the rapid loss of identity of varieties during production cycles. It began with the visits of agronomists and plant breeders to the fields of progressive farmers who took the seeds of new varieties. This was primarily to educate them on seed production. This initiated the process of field inspection and later on found to be very helpful in keeping varieties pure in the production chain. In 1919 formed an International Crop Improvement Association (ICIA), which later on 1969 changed its name to Association of Official Seed Certifying Agencies (AOSCA) paving the way for modern day seed certification. In India the field evaluation of the seed crop and its certification started with the establishment of National Seeds Corporation in 1963. A legal status was given to seed certification with the enactment of first Indian Seed Act in the year 1966 and formulation of Seed Rules in 1968. The Seed Act of 1966 provided the required impetus for the establishment of official Seed Certification Agencies by the States. At present almost all the States in the country have their own Seed Certification Agencies established under the Seed Act, 1966. In great majority of the countries in the World, including India.

Seed certification is a legally sanctioned system for quality control of seed multiplication and production. to maintain and make available to the general public continuous supply of high quality seeds and propagating materials of notified kinds and varieties of crops, grown and distributed to ensure the physical identity and genetic purity. The purpose of Seed Certification is to maintain high quality seeds and propagating materials, to ensure genetic purity, identity and make available to public, through Certification. Seed certification process is consist of six phases as follows Receipt and scrutiny of application, Verification of Seed Source, Field Inspection, Post harvest Supervision, Seed Sampling and Analysis, Labeling, tagging, sealing and Grant of Certification (Fig. 2). In India, seed certification is optional, and labeling is compulsory.

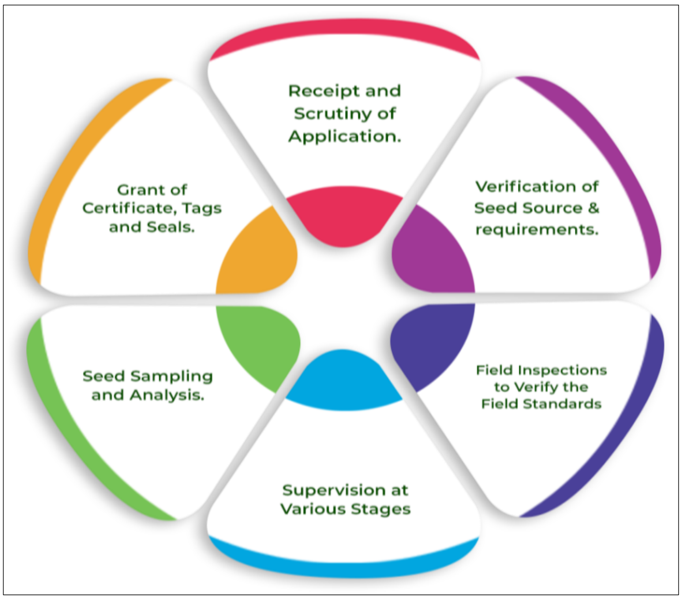

Fig. 2: Seed Certification Process (6) Stages

The Indian Minimum Seed Certification Standards (IMSCS) comprise General Seed Certification Standards and Specific Seed Certification Standards. The General Seed Certification Standards are applicable to all crops which are eligible for certification. The Specific Seed Certification Standards are applicable for the individual crops. Indian seeds programme recognizes three generations of seeds namely breeder, foundation and certified seeds. Foundation and Certified class seeds come under Certification. Breeder seed is exempted from certification as it is produced by the plant breeder which is inspected by a monitoring team consisting of the breeder, representative of seed certification of agency (DDA), representative of NSC. Seeds of only those varieties which are notified under section 5 of the Seeds Act, 1966 shall be eligible for Certification (Fig. 3).

The Seeds Bill, 2019 provides for compulsory registration of "any kind or variety of seeds" that are sought to be sold, if the seed "fails to provide the expected performance under such given conditions", the farmer "may claim compensation from the producer, dealer, distributor or vendor under The Consumer Protection Act, 1986". Hence ensure that action at all stages, namely in field inspection, seed processing, plant inspection, analysis of samples taken and preparing tags, labels, seals, issue of certificates should be taken care with efficiency.

The source seed verification is the first level process in the seed certification process to ensure the seed quality, field inspection to evaluate the crop in the field for varietal purity, isolation of seed crop to prevent out-cross, the value of the seeds for planting will be assessed, allows them to undergo germination and other purity tests required for conforming to varietal purity., the evaluation to check homogeneity of the bulk seed produced as compared with the standard sample is carried out, sample source and final seeds are compared with laboratory tests.

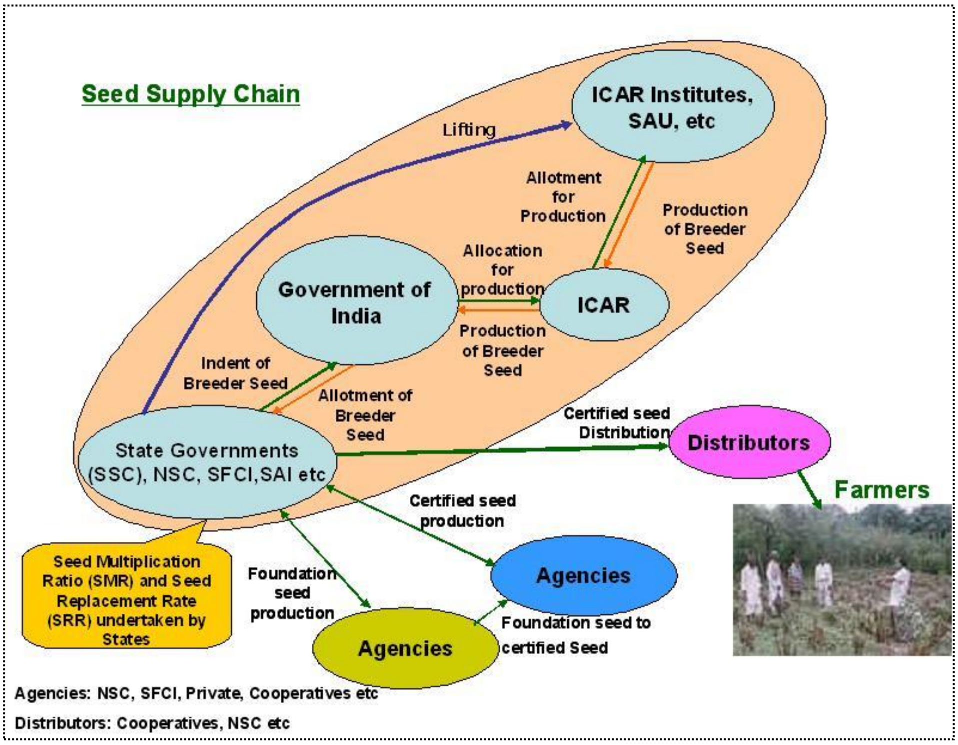

Fig. 3: Seed Supply Chain in India

Minimum numbers of field inspections are necessary to find out field standards of various factors in the seed farm. All the key points to be observed in vegetative stage (pre flowering), flowering stage, pre harvest and during harvest stages, Physical or Genitical Sources of contamination or factors to be observed. Should be taken care in Inseparable Crop Plants of different crops which have seeds similar to seed crop, Objectionable Weed Plants seeds which are difficult to be separated once mixed, which are poisonous, which have smothering effect on the main crop, designated diseases which may reduce the yield and quality of seeds. In the post harvest session processing of seed lot need to be done to remove chaff, stones, stem pieces, leaf parts, soil particles etc from the raw seed lot, grading to bring out uniformity in the seed lot, seed treatment to protect it from storage pests & diseases. The sale of crop seeds with maximum of 3% factors can be taken into account of Immature seeds, Ill-filled seeds, Broken seeds, Stained seeds and over fuzzy seeds. If it containing any prohibited noxious weed seeds may not be sold with more than ¼ of 1% by weight of restricted noxious weed seeds. Seed cannot be sold if it contains more than 2½% of all weed seeds. Moisture content level for long term storage is 6 - 8 %, Short term storage is 10-13% and good quality. Seed genetic purity for Breeder /Nucleus - 100%, Foundation seed - 99.5%, Certified seed - 99.0%. Finally for each class of certified seed labels will be given as follows Breeder Seed – golden yellow, Foundation Seed – white, Registered Seed - light purple, Certified Seed - light blue, Source Identified Seed – yellow (Fig-4). All certification tags will be issued by the certifying agency and printed with the following information: (no changes by the applicant are permitted) i.e. Variety name, Crop, Producer number, Lot number etc (Fig-5 & 6). Every cultivar should able to access healthy seeds which are genetically pure, with high seed vigor and good germination percentage, timely availability of good quality seeds at reasonable price ensures good yield and profit to the farmers is the main objective of NSC. The seed production sector is a vital aspect of agriculture, supporting crop productivity, environmental sustainability, and economic growth.

Fig. 4: Types of Seed Labels

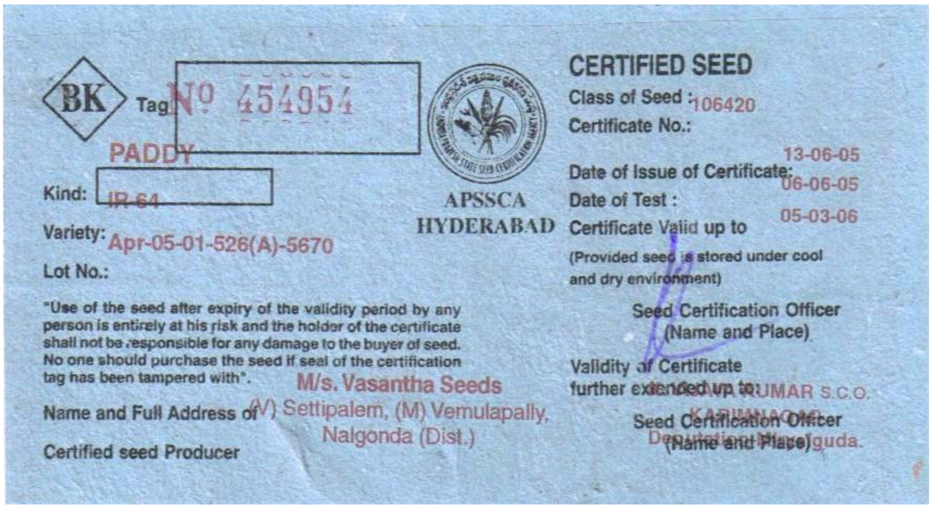

Fig. 5: Modal Seed certification Tag

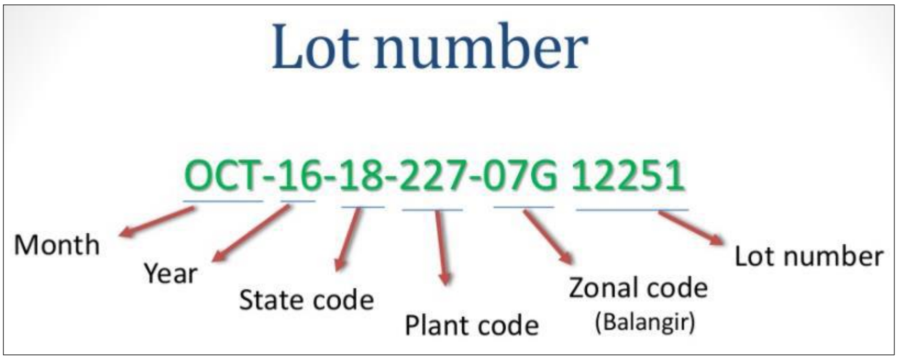

Fig. 6: Modal Seed Lot Number

SEED IN FOOD SECURITY AND SUSTAINABLE AGRICULTURE GROWTH

Seed is the basic and most critical input for sustainable agriculture. The response of all other inputs dependson quality of seeds to a large extent. An improved seed is a most dynamic instrument for increasing agriculture production and also economical input. Indian Seed Development Programme has now occupied a pivotal place in Indian agriculture and is well poised for substantial growth in the future. National Seeds Corporation, which is the largest single seed organization in the country with such a wide product range, has pioneered the growth and development of a sound seed industry in India. NSC, SFCI, States Seeds (Fig. 7).

This map does not indicate the Geographical boundary of India.

Fig. 8: Major Seed Producing States of India Map

India is one of the biodiversity hotspots. India's food, nutritional, livelihood and socio-economic security depends largely upon agriculture and land resources. Future of agricultural production will largely depend upon development of improved varieties/ hybrids in various crops, supported by efficient, cost effective seed production technology. Without good seed, investment like fertilizer, water, pesticides and other input will not pay the desired dividends.

The challenges confronting seed sector are now more than even before due to demand of quality seed of promising varieties to ensure food security. The 1966 legislation was enacted at the time of Green Revolution, when the country hardly had any private seed industry. The high-yielding wheat and paddy varieties, which made India self-reliant in cereals by the 1980s, were developed by the various ICAR institutes and SAUs. Than the public sector institutions have retained their dominance in breeding of wheat, paddy (including basmati), sugarcane, pulses, soybean, groundnut, mustard, potato, onion and other crops, where farmers largely grow open-pollinated varieties (OPV) whose grain can be saved as seed for re-planting. Indian agriculture has earmarked significant advances and the seed industry has played a key role in this endeavor.

The Department of Agriculture and Co-operation is implementing a Central Sector Scheme as 'Development and Strengthening of Infrastructure Facilities for Production and Distribution of Quality Seeds' since 2005-06 for the whole country is to ensure production and multiplication of high yielding certified/quality seeds of all crops in sufficient quantities and make the seeds available to farmers. The developments in the seed industry in India, particularly in the last 30 years, are very significant. Future of agricultural production will largely depend upon development of improved varieties/ hybrids in various crops, supported by efficient, cost effective seed production technology.

For sustainable agriculture, a good quality seed is the most basic and essential input. Other inputs are contingent upon quality of seed for being optimally effective. The Indian seed industry has played a very critical role in the growth of Indian agricultural. Agriculture in India is backed by a strong seed improvement programme involving both the public and private sectors. The Indian seed sector is highly vibrant and energetic and is well recognized internationally.

The global community decided in 2015 to improve people's lives by 2030 by setting 17 global goals for sustainable development. The second goal of this community was to end hunger. Plant seeds are an essential input in agriculture and seed production is always the basic pre-requisite of any food security undertaking. World food production must increase 50% by 2050 to meet the needs of 9 billion people. The growing food demand and rapidly changing climatic conditions across the world motivates us to look for technological solutions to establish effective system for protection of plant varieties, the right of farmers and plant breeders and to encourage development of new varieties of plants that can provide food security for the future generations.

India is signatory of World Trade Organization (WTO). WTO has at least half a dozen intergovernmental agreements that directly affect agriculture. India become a member of OECD Seed Scheme from 23rd October, 2008 and participates in the five varietal certification schemes to facilitate international seed trade. In order to face the challenges of the international seed trade vis-à-vis to ensure the availability of quality seed to Indian farmer, there is urgent need that the Indian scientist, policy makers, seed quality regulators and public and private sector seed producers may join their hands to make India a seed hub on global map.

CONCLUSION

Seed is the basic and most critical input for sustainable agriculture. The response of all other inputs depends on quality of seeds to a large extent. It is estimated that the direct contribution of quality seed alone to the total production is about 15 – 20% depending upon the crop and it can be further raised up to 45% with efficient management of other inputs. Climate change, along with resource depletion and natural disasters, poses formidable challenges to Indian agriculture, largely sustained by smallholder farmers India's progress toward achieving Sustainable Development Goals (SDGs). Seed production helps to preserve biodiversity by maintaining and conserving genetic resources of crops, supports environmental sustainability which is critical for long-term food security. The seed production sector is a vital aspect of agriculture, supporting crop productivity, environmental sustainability, and economic growth. The developments in the seed industry in India, particularly in the last 30 years, are very significant. As India is signatory of World Trade Organization (WTO). WTO has at least half a dozen intergovernmental agreements that directly affect agriculture. Hence there is a need to Establishment of an effective system for protection of plant varieties, the rights of farmers and plant breeders and to encourage development of new varieties of plants that can provide food security for the future generations.

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SEED CERTIFICATION, ORGANIC FARMING AND HORTICULTURAL PRACTICES

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