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Ecology, Biodiversity Conservation and Economic Botany

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UNIT- 1 ECOSYSTEM ECOLOGY

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1.1 INTRODUCTION

Ecology is the study of the interactions of living organisms with their environment. In ecology, ecosystems are composed of dynamically-interacting parts, which include organisms, the communities they comprise, and the non-living (abiotic) components of their environment.

Ecology is known to be the scientific study of the interactions among the organisms and their environment. It is the study of distributions, abundance, and relations of organisms as well as the interactions with the environment. It includes the study of plants and animals' populations, plants, and animal's community as well as the ecosystems.

Ecology is a broad term which is also known as bio ecology, bionomics or environmental biology as it specifically studies the relationship between the organisms and the environment.

It is an interdisciplinary field that deals with both subjects of biology and earth science, however, is separate from the study of the environment, natural history and environmental science. It is environmental science that focused on the interactions between the

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physical, biological and chemical environment components that include their effects on different types of organisms.

This unit will be discussing about Ecosystem Ecology- concept and dynamics – Abiotic and biotic components, energy input in ecosystem, Biomass, primary and secondary production. Concept of food chain and food web – community organization – Concept of habitat, functional role and niche – ecotone – edge effect – ecological succession. Population biology- Basic concepts –Gause's principle, survivorship curves – self- regulating mechanisms.

Species interaction - evolution of cooperation, inter-specific competition, competition coexistence- Negative interaction- predation, herbivory, parasitism - Positive interaction - commensalisms and mutualism.

1.2 OBJECTIVES

- To train students in ecosystem ecology
- To study and impart knowledge about Ecosystem Ecology- concept and dynamics
- To provide students with skills in Abiotic and biotic components, energy input in ecosystem,
- To study about in Biomass, primary and secondary production.

1.3 CONCEPT AND DYNAMICS

Ecology is the science of the environmental inter-relationship between living organisms and environment. Hanns Reiter, a German zoologist, first proposed the term 'ecology (Old spelling Ockologic) in 1865. The word ecology has been derived two Greek words, 'Oikos', meaning the dwelling place or home, and 'logos' meaning discourse or study. So the word ecology literally means the study of living organisms, both plants and animals in their natural habitats or home. Ecology is concerned with the biology of individual organisms and with such groups of organisms as population and communities.

1.4 DEFINITION OF ECOLOGY

- (i) Ecology is the study of the reciprocal relationship between living organisms and their environment- Earnst Haeckel (1866).
- (ii) Ecology is study of plants and animals in relation to their habits and habitats– Colinvaux (1973).
- (iii) Ecology is the study of structure and functions of nature or ecosystem - Odum (1971).
- (iv) Ecology is the scientific study of interactions that determine the distribution and abundance of organism - Krebs (1985).
- (v) Ecology is a science of ecosystems or totality of reciprocal interactions between living organisms and their physical surroundings -Clark, M.E (1973).

- (vi) Ecology is the scientific natural history concerned with sociology and economics of animals - Charles Eton (1927).
- (vii) Ecology is the scientific study of distribution and abundance of organism Andrewartha (1961).
- (viii) Ecology is the science which investigates organisms in relation to their environment and a philosophy in which the world of life is interpreted in terms of natural process - Woodbury (1954).
- (ix) Ecology is the science of inter-relations between living organism and their environment, including both the physical and biotic environment and emphasizing interspecies and intra species relations – Charls et al (1949).

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Ecology is a multidisciplinary field extending across the physical biological and social science Ecology, a branch of Biology, is the multidisciplinary subject. Ecologists use knowledge from many disciplines including Chemistry, Physics, Mathematics and Computer Science. They also rely on such fields as Climatology, Geology, Meteorology and Oceanography.

In simplest term Ecology is the study of mechanisms involved in the interaction between organisms and their environment (i.e.) it intends to study how the organisms influence their environment and how they are in turn, influenced by it (Dhaliwal and Kler 1955)

Ecology, like Biology, has been subdivided into plant ecology and animal ecology.

1. **Plant ecology:** It deals with the relationship between plants and their environment. It embraces many aspects of the life of a plant.
2. **Animal ecology:** It deals with study of relationship between animals and their environment.

W.B. Turril comments that plant ecology is intensive.

1.5 PLANT ECOLOGY AND ITS DIVISION

Plant Ecology is generally of two types as follows:

1.5.1. Autecology: It is concerned with the study of individual organisms or species or its population throughout its life history in relation to its environment. Autecology forms a basis for the study of Synecology

1.5.2. Synecology: It is the study of groups of organisms comprising different species in relation to environment So Autecology is the study of individuals or populations and Synecology is the study of plant communities.

Autecological studies of some plants have been done as follows:

(a) **Trees:**

- (i) *Boswellia serrata* (Sharma, 1955).
- (ii) *Tectona grandis* (Bhatia, 1954).

(b) **Grassland and Wasteland herbaceous species:**

- (i) *Euphorbia hirta*, *Euphorbia thymifolia*, *Setaria glauca* (Ramkrishnan, 1960).

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- (ii) *Cyperus rotundus* (Ambasht, 1964, Tripathi, 1965)
- (iii) *Anagallis arvensis* (Pandey, 1968)
- (iv) *Xanthium strumarium* (Kaul, 1959) M
- (v) *Alhagi camelorum* (Ambasht, 1963)
- (vi) *Alysicarpus monilifer* (Maurya and Ambasht, 1973)

Autecological studies have also been done on several medicinal plants at Varanasi. Synecological works have been done in forests, grassland, deserts, fresh waters and other specialized habitats.

Ecology may be divided into various subdivisions on the basis of objectives of study (Kendeigh, 1974) as follows:

1. The local and geographical distribution and abundance organisms (habitat, niche, community, biogeography).
2. Temporal changes in the occurrence, abundance and activities and activities of organisms (seasonal, annual sessional geological).
3. The interrelation between organisms in populations, and communities (Population ecology)
4. The structural adoption and functional adjustments of organisms to their physical environment (physiological ecology).
5. The Behaviour of organisms under natural conditions (ethology)
6. The evolutionary development of all these inter-relations (Evolutionary ecology).
7. The biological productivity of nature and how this may best serve mankind (Ecosystem ecology).
8. The development of mathematical models to relate interaction of parameters and predict effects (systems analysis).
9. Man's relation to environment. Specially man's effects on biosphere and implications of these effects for human (Human ecology).
10. Optimization of agricultural production with least deterioration of natural resources and environment (agricultural ecology)

Many practical application of ecology may be grouped together as applied ecology. This may includes wildlife management, range management, forest conservation, pest management, epidemiology, animal husbandry and agriculture

1.6 ABIOTIC AND BIOTIC COMPONENTS

No organisms or species lives along in the world an organism is always in the state of perfect balance with the environment. The environment refers to the things and conditions around the organism which directly or indirectly influence the life and development of organism and their population. The structural and functional system of communities and their environment is called ecological system or in short the ecosystem. Ecosystem is essentially a technical term for nature that was previously used by many ecologist. The ecosystem is the basic functional unit in ecology since it includes all the living organism in an

area interacting with the physical environment. A.G. Tansley, a British ecologist first proposed the term 'Ecosystem' in the year 1935.

1.6.1 Definition

- (i) The ecosystem or ecological system is the basic functional unit of organism and their environment interacting with each other and within their own components –E.P. Odum (1971)
- (ii) Ecosystem is a functional unit where biotic and abiotic components of the environment interplay with each other. - Tansley (1935)
- (iii) The organisms and the physical features of the habitat form an ecological complex or more briefly an ecosystem Clark (1954)
- (iv) Ecosystem is a complex in which habitat, plants and animals are considered as one interesting unit, the materials and energy of one passing in or out of the others.- Woodbury (1954)

1.6.2 Components of Ecosystem

The earth upon which we live may be considered a vast ecosystem. The portion of the earth where biotic components are present is called the 'biosphere' or 'ecosphere', the biosphere obtains its energy from sun and the abiotic (i.e. non-living) materials from the soil (i.e. lithosphere), water (i.e. hydrosphere) and air (i.e. atmosphere),

The ecosystem is generally divided into two components on the basis of functional principles (Tansley, 1966) as follows:

1. Abiotic Components (i.e. non-living components): It is divided into three different types as follows:

- (i) **Inorganic components:** Soil, minerals, water and various gases together constitute the Inorganic components of ecosystem. Minerals are mixed with water and at the same time various gases are dissolved in water of the soil which is known as soil solution. Plants absorb the soil solution and prepare food by the process of photosynthesis, the food manufacturing process in green plants.
- (ii) **Organic components:** Various dead and decomposed bodies of the organism and excretory materials of different organisms mix up with the soil and form organic components.
- (iii) **Physical components:** The weather controlling elements (e.g. sunlight, temperature, rainfall, atmospheric humidity etc.) constitute the physical components.

2. Biotic Components: Plants, animals and microbes constitute the biotic components of ecosystem. The living organisms of the ecosystem are divided into two components on the basis of the method of food collection as follows:

(i) Autotrophic components: (Greek: Auto = self and tropho = to feed). The living organisms of the biotic components capable of manufacturing their own food from the abiotic components is called autotrophs. The green plants are known as autotrophs, because they are capable of manufacturing food from the abiotic components by the process of photosynthesis. So the green plants are called 'Producers'. The term

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producer is misleading one in energy context. Producers produce carbohydrate and not energy. Since they convert or transduce the radiant energy in the chemical form, E.J Karmondy suggests better alternative term 'converters or 'transducer. But because of wide use, the term producer is still retained. The producer is also called Tropic level-1'.

(ii) Heterotrophic components: (Greek: Heteros= another, tropho = to feed): The heterotrophic components include non-green plants and all animals which takes food from autotrophs. Heterotrophs mean other nourishing in which the organisms utilize, rearrange, and decomposes the complex materials synthesized by autotrophic components. The heterotrophs cannot produce their own food. Almost all the animals except one or two (e.g. *euglena*, *crysomoeba*, etc.) and nor green plants depend on autotrophs directly or indirectly. So they are called 'Consumers' or Phagtophs (Phago = to eat). Consumers are of three types according to the nature of food as follows

(iii) Herbivores (Herb = plant, vore = to devour): The consumer that depend on green plants for their food are called 'herbivores'. The herbivores are included in the category of primary consumer.

***Example:** Cow, goat, buffalo, deer, insects, rodents, rabbit etc.

Elton (1939) named herbivores of ecosystem as 'key industry animals. The herbivores serve as the chief Source of food for the carnivores.

(iv) Carnivores: (Carnish -flesh, vore = to devour). The consumers that depend on other living organism (i.e. animal) for their food are called 'carnivores'. **Example:** Lion, tiger, crocodile, shark etc.

(v) Omnivores: (Omnis= all, vore = to devour): The consumers that are adapted to consume herbivores as well as plant (i.e. producer) are called 'omnivores. **Example:** Man etc.

Consumers are of three types on the basic of trophic level as follows

(i) Primary consumer: They are totally herbivores animals. They depend on the producer plants for their food. The herbivores serve as a chief sources of food for the carnivores **Example:** Cow, goat, deer, rabbits, fish, snail, insects, etc.

(ii) Secondary consumers: The carnivores and omnivores animals feed on the herbivores and they are called ' secondary consumer. The carnivores are flesh eating animals and omnivores are adopted to consume herbivores as well as carnivores. **Example:** Dog, wolf, fox, crow, cat, snake, fog, toad etc.

(iii) Tertiary consumer: The animals that feed on secondary consumer are called 'tertiary consumer. They are the top carnivores and they prey upon carnivorous animals or green Example: Tiger, lion, eagle, shark, vulture etc. Besides these, parasites, scavengers and saprobes are also included in the consumer. The parasitic plants and animals utilize the living tissue of different plants and animals but the scavengers and saprobes utilize dead remaining of plants and animals as their food.

3. Decomposers: The organisms depends on dead remains of producers and consumers for their food are called 'decomposers. They attack the

dead remains of producers and consumers and degrade the complex organic substance into simple compounds. They are micro consumers
Example: Protozoa, bacteria, fungi etc.

4. Transformers: The organisms that change the organic compounds into inorganic form which are suitable for the reuse by the green plants (i.e. producers) are called 'transformers' **Example:** Fungi, saprophytic organism etc.

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1.7 DIFFERENT TYPES OF ECOSYSTEM

The ecosystems are of two types as follows:

(i) Natural Ecosystem: It is self regulating system without much direct interferences and manipulations of human beings Example: Pond, lake, stream, sea, ocean, forest, grassland desert etc.

(ii) Artificial Ecosystem: The man made ecosystems are called 'artificial ecosystem' Example: Garden, park, road, vegetable garden, and crop land balanced aquarium etc.

People able to get their food, cloth, timber, medicine and other useful plant products from crop ecosystem. In city ecosystem, Road Park, houses etc. are built-up according to the desire of local people.

1.8 IMPORTANCE OF ECOSYSTEMS

The importance of ecosystem is as follows

- (i) The green plants are the primary producer in all ecosystem and maintain an equilibrium of carbon dioxide and oxygen in the atmosphere
- (ii) The ecosystem maintains natural resource such as forests wildlife and other biotic communities
- (iii) The natural calamities such as flood and drought can be controlled by ideal ecosystem.
- (iv) The environmental pollution (e.g. air, soil, water etc.) can be minimized by ecosystem
- (v) The biochemical cycles such as hydrological cycle, carbon cycle, nitrogen cycle etc. can be controlled by ecosystem.
- (vi) The biodiversity can be maintained by ecosystem.
- (vii) The ecosystem helps to maintain the fertility of soil and control of soil erosion.
- (viii) The balanced ecosystem maintains the productivity of plants and animals.

1.9 ECOSYSTEMS OF THE WORLD

The ecosystem of the World are divided into two types as follows:

1.9.1 Terrestrial Ecosystems:

This ecosystems are governed by annual variation of temperature, rainfall, availability of nutrients and sunlight.

This ecosystems are of different types as follows:

- (i) Forest ecosystem
- (ii) Grassland ecosystem.

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- (iii) Desert ecosystem.
- (iv) Tundra ecosystem
- (v)

1.9.2 Aquatic Ecosystem:

This may be further distinguished as follows

- (i) Marine ecosystem (i.e. ocean ecosystem).
- (ii) Fresh water ecosystem: This may be of two types as follows:
 - (a) Lotic (i.e.) running water as stream, river etc.
 - (b) Lentic (i.e.) stagnant water as Lake Etc.

1.10 SOME EXAMPLES OF ECOSYSTEMS

(1) Forest Ecosystem: In those regions of the world where there is plenty of rainfall, the climax vegetation is the forest. Forest to occupy roughly 40 percent of total land, In India, forest Occupies one tenth of total land area. There are two main components of forest ecosystem as follows

(a) Abiotic components: In a forest ecosystem, soil, ale moisture and sunlight form the abiotic or physical components

(b) Biotic components: There are three important classes of biotic components as follows)

i) Producer: All green plants of a forest are producer and they are main sources of food for all the animals.

Example:

(a) Tropical moist deciduous forest Tree: Sal (*Shore robusta*), teaks (*Tectona grandis*) sandal wood (*Santalum album*) etc.

(b) Tropical moist evergreen forests Tree: Mango (*Mangifera indica*), crape myrtle (*Lagerstonia flosriginae*) champa (*Michelia champaca*), arjun (*Teminallia arjuna*) etc.

Shrubs: *Bauhiniasp, Diospyrossp, Ziziphus* sp etc.

Grass: *Panicumsp, Cyanodon dactylon, Andropogon, Heteropogon* etc.

(ii) Consumers: There are a number of consumers in the forest as follows

(a) Primary consumers: Primary consumers are herbivorous animals and they feed on producers (i.e.) green plants).

Example: Insects (e.g. ant, fly, beetle, grass hopper, leaf hopper, spider etc.), elephant, deer, squirrel, bat flying fox etc.

(b) Secondary consumers: Secondary consumers are carnivorous animals and they feed on primary consumer.

Example: Bird, snake, lizards, jackals etc.

(c) Tertiary consumers: Tertiary consumers are top consumers and they feed on secondary consumers.

Example: Tiger, lion, hawk etc.

iii) Decomposers and transformers: These are microorganism that attack dead bodies of producers and consumers and they convert complex

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organic compounds into simpler Inorganic compounds and elements. These free elements again return to the abiotic components and are reutilized by the producer in their nutrition. Example: Fungi (species of *Aspergillus*, *Fusarium*, *Alternaria*, *Polyporus* etc.), bacteria (species of *Bacillus*, *Pseudomonas*, *Clostridium*, etc.)

(2) Pond and Lake Ecosystem: Pond and lake are a fresh water ecosystem. There are two main components as follows

(a) Abiotic components: It consists of water, dissolved minerals, oxygen and carbon dioxide, solar radiation the main source of energy.

(b) Biotic components: On the basis of water depth and types of vegetations and animals, there may be three zones in a pond as follows:1

(i) Lithoral: It is shallow water region which is usually occupied by rooted plants.

(ii) Limnetic: It ranges from the shallow to the depth of effective light penetration and associated organisms are small crustaceans, rotifer, fish's insects and their larvae, algae etc.

(iii) Profundal: It is deep water parts where there is no effective light penetration. The associated organisms are snails, mussels, crabs, worms etc

(1) Producers: All green (plants of pond and lake are producers. In pond ecosystem, producers are of two types as follows.

(i) Macrophytes: Macrophytes grow in shallow water. They are partly or completely submerged rooted large plants. Hydrilla, Vallisneria, Trapa, Typha, Nymphaea etc. are included in this group. There are some free floating macrophytes such as Azolla, Lemna, Pistia, Salvinia, Walfia etc.

(ii) Microphytes: Microphytes are minute floating plants they are also called phytoplankton. Different types of fungi like Oedogonium, Spirogyra, Ulothrix are the examples of this group. The green plants convert the radiant into chemical energy through the process of photosynthesis. The chemical energy stored in the form of food is utilized by all living organisms in respiration.

(2) Consumers: There are number of consumers in pond and lake ecosystem as follows:

(i) Primary consumers: In pond ecosystem, some herbivores are present which consume green plants and algae as their food. The primary consumers are of two types such as zooplankton. (e.g. Amoeba, Daphnia, Cyclops etc.) and benthos (e.g. snails, small fishes etc.)

(ii) Secondary consumers: The herbivorous aquatic animals are the food for secondary consumers.

Example: Frog, big fishes, water snake, etc.

(iii) Tertiary consumers: They feed secondary consumers. Examples: Water birds, turtle etc.

(3) Decomposers and Transformers: When aquatic plants and animals die, a large number of fungi and bacteria attack their dead bodies and convert the organic substances into simpler inorganic compounds and

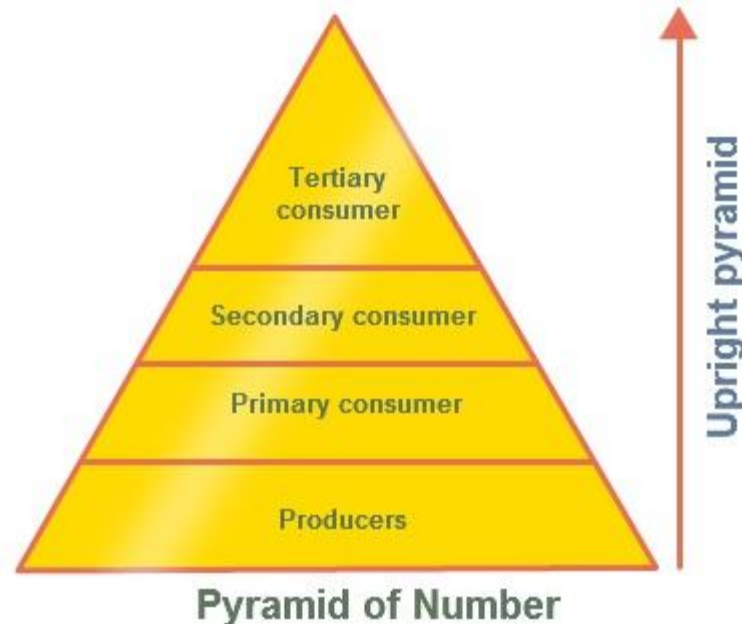
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elements. These microorganisms are called decomposers (eg. bacteria and fungi like *Aspergillus*, *Fusarium*, *Rhizopus*, etc.) The organic compounds are changed into inorganic form and are suitable for reuse by the producers (i.e. green plant), by the organisms called “Transformers”.

1.11 ENERGY INPUT IN ECOSYSTEM

The method of transfer of modified solar energy from producer (i.e. producer- consumer- Decomposer) through different trophic level of ecosystem is called Energy flow

The sun is the main source of energy. There are different methods of transfer of energy in ecosystem as follows:



Energy flow and Pyramid of ecosystem

(i) The green plants entrap the solar energy in the form of potential energy into the food (e.g. carbohydrates, fats protein etc.). Primary consumers eat the producer (i.e. green plants). As a result, energy flows from producer to primary consumer, primary consumer to secondary consumer secondary consumer to tertiary consumer and at last to the top consumer.

(ii) The energy flow in ecosystem is unidirectional. The solar energy being entrapped in green plants and flows in different trophic level through the food chain. In the ecosystem, energy flows from producer to the tertiary consumer. But there is no scope of flowing the energy from the tertiary consumer to the producers.

(iii) In the ecosystem, there is no scope of cycling energy.

(iv) The green plants store the energy as potential energy (chemical energy) In an ecosystem, the energy flows from producer through different trophic level. The herbivores or primary consumers eat green plant as their foods directly and energy is taken by them. But here energy

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transfer does not occur 100 percent in successive trophic level. Each trophic level gains only 10 percent energy from previous trophic level and the remaining energy (i.e 90 percent) is dissipated as heat or lost by other ways, The secondary consumers takes 10 percent energy from primary consumer The tertiary consumer takes 10 percent energy from secondary consumer and so on. This is called "**Ten Per Law of Linderman**". The scientist Linderman explains the diminishing characteristics of energy flow through this renowned law in 1942.

(v) The energy flow is based on two important laws of Thermodynamics as follows:

a) The first law of thermodynamics: It states that the amount of the energy in the universe is constant. It may change from one form to another but it can neither be created nor destroyed

b) The second law of thermodynamics: It states that energy decreases during transformation. In ecosystem the transformation of solar energy in green plants follows the first law of thermodynamic and energy loss in different trophic level follows the second law of thermodynamics.

1.12 BIOMASS, PRIMARY AND SECONDARY PRODUCTION

In ecosystem, the energy flow is shown below

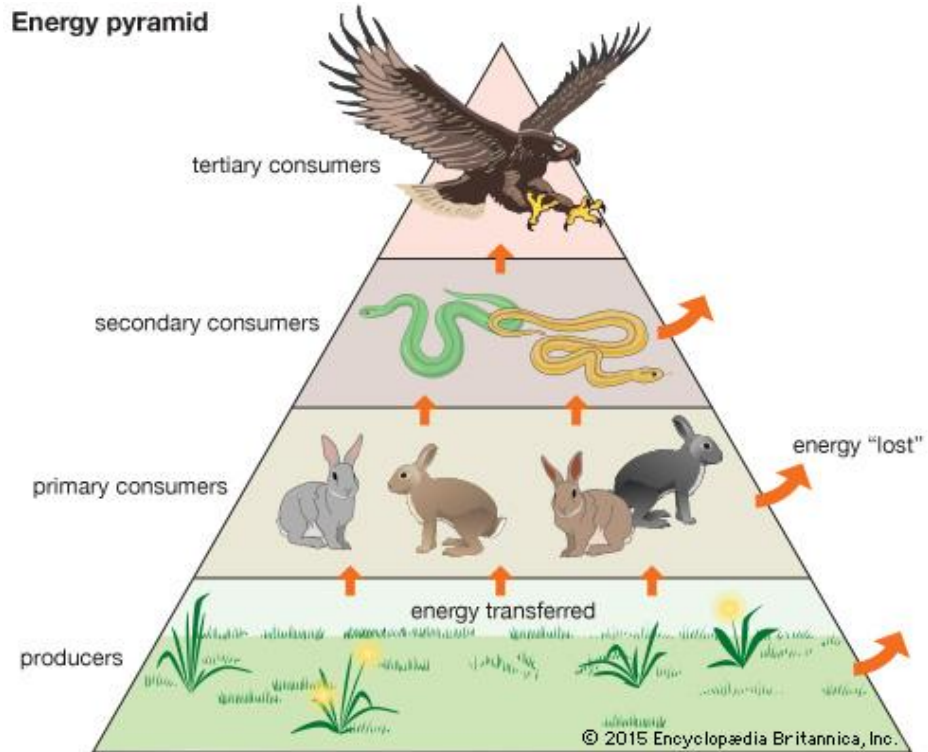
Energy → Energy → Energy → Energy

(i) Solar energy → Green plants → Deer → Tiger → Vulture (Producer) (Primary (Secondary (Tertiary consumer) consumer) consumer)

Green → Grass → Frog → Snake → Vulture

(ii) Solar energy → plants → hopper → (Producer) (Primary (Secondary (Tertiary Top consumer) consumer) consumer) (consumer) (consumer)

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Check your Progress -1

Note: a. Write your answer in the space given below

b. Compare your answer with those given at the end of the unit.

1. Define "Ecology"

2. Who coined the term ecosystem?

1.13 LET US SUM UP

In this unit you have learnt about basic concept related to the environment and ecology. Environment is the sum total of all conditions and influences that affect the development and life of all organisms on earth. Ecology is the branch of science that deals with the study of interactions between living organisms and their physical environment. Ecology, like Biology, has been subdivided into plant ecology and animal ecology.

Plant ecology Plant Ecology is generally of two types as follows:

1. Autecology **2. Synecology**

Animal ecology

- **Biotic and abiotic components**
- **Types and importance of ecosystem**
- **Producers, Consumers , decomposers and transformers**
- **Energy inputs in an ecosystem**
- **Biomass and energy production**

1.14 UNIT - END EXERCISES

1. Abiotic and biotic components
2. Food chain and food web
3. Gause's principle
4. Commensalisms and mutualism

1.15 ANSWER TO CHECK YOUR PROGRESS

1. Ecology is the study of the interactions of living organisms with their environment.

2. A.G. Tansley, a British ecologist first proposed the term 'Ecosystem' in the year 1935.

1.16 SUGGESTED READINGS

1. James P. Kimmins, 2003, *Forest Ecology* 3rd edition Benjamin Cummings Publisher. ISBN: 0130662585
2. Peter Stiling, 2001, *Ecology- Theories and applications* ISBN: 013091102X.
3. Jessica Gurevitch, 2006, *The Ecology of Plants* Sinauer Associates; 2nd edition ISBN: 0878932941
4. Gary W. Barrett, Murray Barrick and Eugene Odum, 2005, *Fundamental of Ecology*, Cengage Learning, ISBN: 9788131500200

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UNIT - 2 CONCEPT OF FOOD CHAIN

Structure

- 2.1 Introduction
- 2.2 Objectives
- 2.3 Concept of Food Chain
- 2.4 Concept of Food Web
- 2.5 Ecological Niche
- 2.6 Community Organization
- 2.7 Ecotone and Edge Effect
- 2.8 Ecological Succession
- 2.9 Let us sum up
- 2.10 Unit end Exercises
- 2.11 Answer to check your progress
- 2.12 Suggested readings

2.1 INTRODUCTION

A food chain only follows just one path as animals find food. E.g: A hawk eats a snake, which has eaten a frog, which has eaten a grasshopper, which has eaten grass. A food web shows the many different paths plants and animals are connected. E.g: A hawk might also eat a mouse, a squirrel, a frog or some other animal. A food web is a graphical model depicting the many food chains linked together to show the feeding relationships of organisms in an ecosystem. It differs from a food chain in a way that the latter is a linear system showing a succession of organisms whereby each species is eaten in turn by another species

Edge effect refers to the changes in population or community structures that occur at the boundary of two habitats (ecotone). Sometimes the number of species and the population density of some of the species in the ecotone is much greater than either community. This is called edge effect. Ecological succession is the process of change in the species structure of an ecological community over time. The time scale can be decades (for example, after a wildfire), or even millions of years after a mass extinction

2.2 OBJECTIVES

- To instill in students Concept of food chain and food web
- To student study about community organization, Concept of habitat, functional role
- To study about in niche – ecotone – edge effect – ecological succession.

2.3 CONCEPT OF FOOD CHAIN

Definition: The transfer of food energy from the source in plants through a series of organisms with eating and being eaten is referred to as 'food chain'. -Odum (1966)

The linear sequence of acquiring nutrition in ecosystem is known as food chain'

Food chains are of two types as follows:

(1) Grazing food chain:

It starts from green plants (i.e producer) and goes through herbivores (i.e organism feeding an green plants) to the carnivores (i.e eating animals). In this food chain, the energy is distributed from producer (i.e green plant) to herbivores and carnivores. Here the producer entraps energy into the food, synthesized by the green plants through the process of photosynthesis. The primary consumer eats the producer, secondary consumer eats the primary consumer, tertiary consumer eats the secondary consumer and So on. As a result, a good food chain forms.

Example:

(a) Terrestrial food chain

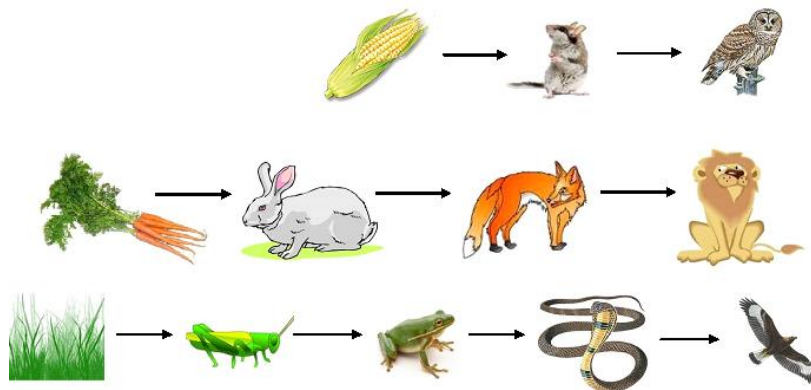
(i) Plant → Hare → Fox → Vulture
 (Producer) (Primary consumer) (Secondary consumer) (Tertiary consumer)

(ii) Plant → Deer → Tiger → Vulture
 (Producer) (Primary consumer) (Secondary consumer) (Tertiary consumer)

(iii) Grass → Grass hopper → Black bird → Falcon
 (Producer) (Primary consumer) (Secondary consumer) (Tertiary consumer)

(iv) Grass → Grasshopper → Lizard → Falcon
 (Producer) (Primary consumer) (Secondary consumer) (Tertiary consumer)

(v) Green plant → Insect → Frog → Snake → Vulture
 (Producer) (primary consumer) (Secondary consumer) (Tertiary consumer) (Top consumer)



Grazing food Chain

(2) Detritus food chain:

The dead organic remains including metabolic wastes and exudated derived from grazing food chain are generally termed as 'detritus. The energy contained in detritus is not lost in ecosystem as a whole, rather it serves as a source of energy for a group of organisms

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called detritivores that are separated from the grazing food chain. The food chain so developed is called 'Detritus food chain; Earth worm, termite, worm etc, are the example of detritivores

Example:

Plant → organic matter → Insect → Small fish → Big fish
(Producer) (Decomposer) (Primary consumer) (Secondary consumer) (Tertiary consumer)

Besides these there are also two types of food chain as follows:

i) Predator food chain: The food chain that goes on alternatively from small organism to large organism is called Predator food chain

Example:

Grass → Grass hopper → Frog → Snake → Peacock
(Producer) (Primary consumer) (Secondary consumer) (Tertiary (Top Consumer) consumer)

ii) Parasitic food chain: The food chain that goes alternatively from large to smaller one is called Parasitic food chain

Example:

Plant → Man → Worm
(Producer) (Primary consumer) (Secondary consumer)

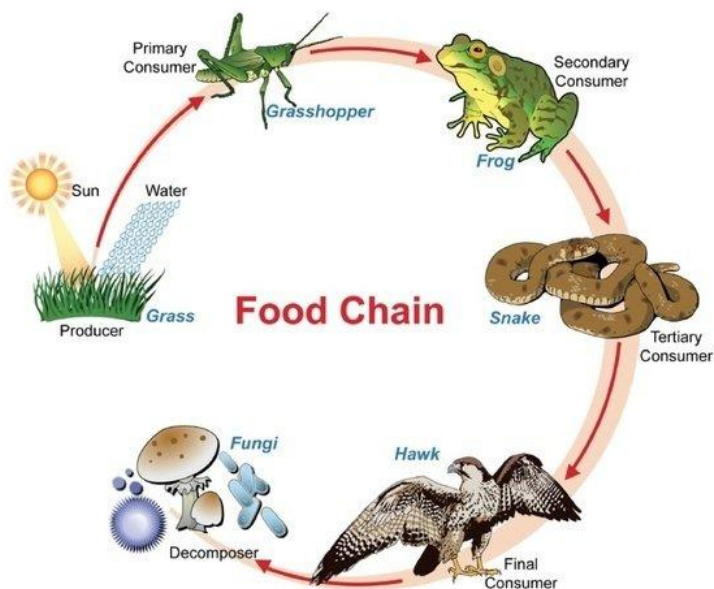


Fig.4 Grazing Food chain

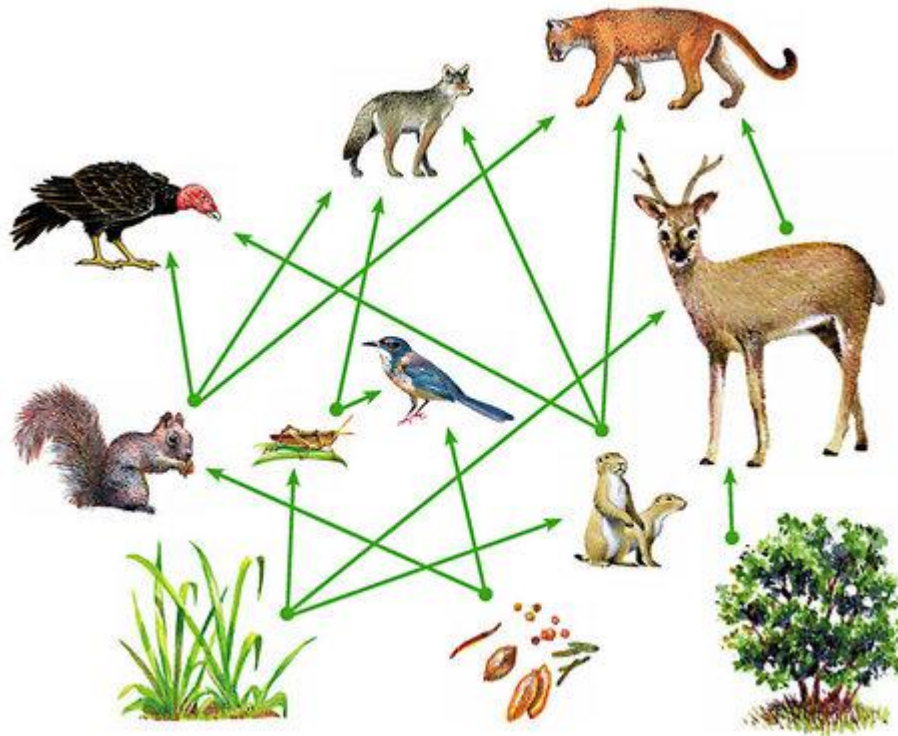
2.4 CONCEPT OF FOOD WEB

In an ecosystem, several inter connected food chain forms a network, some time with side chain also, is called Food web. A complex of interrelated food chains makes up a food web. Food maintains the stability of the ecosystem

Example: Geographic level x Fourth Hare cases from al in size e top from Falco Ceai Dead body ture Deer Shrbs Hebs Aige Corms tuber P t

ome FA Primary Corumer Hairy nism to energy oducer) es and restrial stem pond Teriary Faicon Fig. 7.7 Food WebFue webs are formed in grass land ecosystem based on grass as follows Tiger Bird Hare)Grass Grass hopper i) Grass Ca) Grass Ov) Grass Vulture Rat Lizard Vulture Vulture Grass hopper Snake Rat (v Grass CO Fruit Leaf Decomposition Excreta Nitrogen fixingn Bacferia Fungus & Bacteria Bacteria C Protozoa Fig.7.8 Position of food web in ecosystem

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Food Web

2.5 ECOLOGICAL NICHE

The location and function of an organism in the context of its ecosystem is spoken of as its niche. The total role of a species in the community is the ecological niche. The ecological niche includes the following

- i) The species of organisms
- ii) Environmental factors
- iii) The area in which the species live.
- iv) The specialization of species population within a community.

Odum (1971) has classified the ecological niches into following types:

- i) Habitat niches: Habitat niches are concerned with habitats of the organism.
- ii) Trophic niches: Trophic niches are related to physiological modification.
- iii) Geographical niches: Geographical niches are related to geographical modification.

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2.6 COMMUNITY ORGANISATION

All the living things make the biotic system of the earth. Neither organisms nor species populations exist by themselves in nature, but are populations living together in the same area. Any assemblage of populations of living organism in the prescribed area or habitat is termed biotic community. For example, the different species of organisms occurring in a pond constitute the pond community. Some other communities as swamps, deserts, large lakes, grass lands and many others of different dimensions. Similarly, the independent species in any environment, such as a forest, lawn or a desert track, constitute community may be composed primarily of animals, or primarily of plants but most communities consist of both animals and plants. The factors that influence the living organism are known as biotic factor. A population of single species is not a viable entity by itself. It will be not be able to survive for long. For example, the sparrows require worms, insects or seeds or some other kind of food. Thus the most appropriate definition of biotic community-a biotic community is a naturally occurring assemblage of plants and animals that live in the same environment are naturally sustaining and interdependent, and are constantly fixing and dissipating energy.

However the different species in a biotic community share a common environment and their relationship are based on direct or indirect functional interactions. The nature of relationship is determined by the requirements of the members of the community.

Biotic community organization results from interdependence and interaction among population of different species in a habitat. Large number of biotic communities found in nature due to two specific reasons. They are as follows:

- i) Existence of diverse habitats with characteristic environmental conditions and
- ii) Co-occurrence of different species whose tolerance ranges overlap with the environmental condition obtained in that habitat. When similar habitat conditions are repeated at another location the same biotic community gets established there.

Characteristics of Community

Each biotic community consists of very diverse organism belonging to different kingdoms of living things. The number of species and abundance of population in communities also vary greatly. As mentioned earlier, the organisms in a community depend upon each other as well as non-living environment for food, shelter and reproduction

Species composition: The kinds of plants and other organisms present in a community indicate its species composition, which differs from one community to another. Sometimes, in the same community there may be seasonal variation in plants species

Each species of community has got definite range of tolerance towards the physical and biological environmental conditions of the habitat. The range of environment a species can tolerate is called its ecological amplitude. The nature of community of a particular habitat is determined by the species, and physical and biotic influences prevailing in the locale of community.

Dominance: A biotic community may have major categories of growth forms, such as trees shrubs, herbs and mosses. Out of hundreds of species present in the community, relatively only a few exert a major controlling influence due to their large size, numbers of activities. The phenomena is called dominance. "Dominant species are those which are highly successful ecologically and which determine to a considerable extent the conditions under which the associated species must grow.

The dominance in the community may be the result of co-action between two or more es Different communities are generally recognized and named on the basis occurring in them. For example, a forest community in which pine trees are dominant is called pine forest Grassland represents a community which has grass species dominating over the other herbs Sometimes, communities are named after environmental factors, such as desert marine community, mangrove vegetation, etc.,

Physiognomy: General appearance of vegetation is referred to as physiognomy. It constitutes pal stature, shape and life-forms of the species comprising the vegetation and actually the classification of vegetation types has been done on the basis of physiognomy. The species of a community can be grouped into several life forms on the basis of general appearance and growth.

2.7 ECOTONE AND EDGE EFFECT:

The zone where two or more different communities meet and rate, is called transition zone or ecotone. This zone of integration may be narrow or wide, cal (eg,a zone between field and a forest) or regional (eg, the transition between forest and s land) Ecotone contains few species from both communities. The total number of species is often greater in the ecotone than in the adjoining communities. The ecotone or transition zone exhibits a shift in dominance of the conspicuous species of both sides. It may also include a number of highly adaptable species that tend to colonize such transitional areas. Because of this, variety (i.e, species diversity) and density of life is often greatest in such areas. This potential for the ecotone to act as a habitat for species found in neither major community called edge effect. Thus the tendency of increased variety and density of some organism at the community border known as edge effect. The organisms that occur primarily, or most abundantly, or spend reatest amount of their time in junctions between communities are called edge species. A common example of the edge effect in action can be seen in

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those species of owl that live in or s ecotones between forests and grasslands. They depend on forest trees for nesting and do their hunting in the grassland, where they depend on field rodents for food

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In man-made communities such as agricultural fields, the ecotone between the field and the forest act as refuge for species formerly found in woods. Ecotones of this type are also the prime habitat of many species of insects, game birds and mammals

2.8 ECOLOGICAL SUCCESSION:

1. Plant succession is an orderly process of community change in unit area. -E.P Odum
2. Plant succession is a competitive drift in which at each phase until the climax, the constituent species render the habitat more favorable to their succession than to themselves. – Salisbury
3. Succession is a natural process by which the same locality becomes successively colonized by different groups or communities -Clements

Plant community can be compared to an individual organism with a developmental history. This developmental history is called plant succession. In ecology, succession means an orderly sequence of communities of plant which occurs over a period of time at the same place. Odum (1969) has given three attributes of succession as follows:

- i) It is an orderly process of community development that is reasonably directional and therefore predictable.
- ii) It results from modification of the physical environment by the community, that is, succession is community controlled even though the physical environment determines the pattern, the rate of change often sets limits as to how far the development can go.
- iii) It culminates in a stabilized ecosystem in which maximum biomass (or high information content) and symbiotic function between organisms are maintainable per unit of available energy

Succession is a complex universal process which begins, develops and finally stabilizes at the climax stage. The climax is the final, mature, stable, self-maintaining and self-reproducing stage of vegetation development in a climatic unit. Succession is generally progressive and thus it brings about

- i) Progressive changes in the soil conditions or habitats. These changes bring the habitat from extreme to optimum conditions of plant growth and
- ii) Progressive changes in life forms or phytads

Kinds of Succession

Depending on the nature of bare area on which it develops, the succession may be of two kinds' viz. primary succession and secondary succession

(1) **Primary succession:** The succession that starts on the extreme bare area on which there was no previous existence of vegetation is called primary succession or presere. In primary succession, the area the first time.

(2) **Secondary succession:** The succession that starts on secondary bare area which once occupied by original vegetation but later on became completely cleaned of vegetation by the process called denudation is called secondary succession. The denudation process is brought about by destructive agencies such as burning, grazing, cleaning, felling of trees etc. Denudation causes the land bare or naked. The succession progressing on naked area is also termed as sub sere. Usually the rate of secondary Succession is faster than that of primary succession. Because of better nutrient and other condition in area previously under plant cover. Successions are called autotrophic and heterotrophic depending on the predominance of green plants or heterotrophic organism. In autotrophic succession initially green plants are much greater in quantity than animals and this takes place in a medium rich in Inorganic substances. In heterotrophic succession, the population of heterotrophic organisms like fungal, bacteria and animals are in greater quantity at the initial stage and such a succession begins in a medium rich in organic matter.

Successions are of two types depending on predominance of green plants of heterotrophic organisms in the initial serial stage as follows

- (i) Autotrophic succession: In this succession, initially green plants are much greater in quantity than animals and this takes place in medium rich inorganic substance
- (ii) Heterotrophic succession: In this succession, the population of heterotrophic organisms like bacteria, fungi and animals are in greater quantity at the Initial stage and such a succession begins in a medium rich in organic the and the matter

Successions are of two types due to modification of the environment by the communities themselves as follows in for

- (i) Autogenic succession: In this succession, the effect of community on the environment becomes the cause of succession on inal of led
- (ii) Allogenic succession: In this succession, replacement of one community by another is largely due to forces other than the effects of communities in the environment

Causes of Succession

The main causes of succession are as follows

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1. **Climatic causes:** Climate determines the vegetation of an area. Plants can not adjust with the long range variation in the climate. The fluctuating climate sometime leads to the total or partial destruction on the other hand, the plants that are better adapted in the changed climate starts their appearance.
2. **Topographic Causes:** The nature of topography influences the plant succession. The topography changes due to soil erosion and soil deposition. Deposition results in a new bare area on which succession of vegetation starts.
3. **Biotic Causes:** Biotic causes (ie grazing, cutting, cleaning cultivation, harvesting, deforestation etc.) influence in the vegetation change of an area. An enumeration of various stages of succession which are characterized by similar series of stages, whether in primary or secondary, hydrosere, Xerosere or halosere may be advantageous Ganguli *et al.* 1972)
 1. **Nudation:** The formation of the bare areas by natural causes or artificially
 2. **Colonization and aggregation:** After establishment of the first scattered invaders, the individuals come to be grouped as a result of propagation
 3. **Ecesis:** Adjustment, establishment and final attainment of maturity of the colonizing species of plants that have migrated from neighboring areas to new situations. It essentially consists of three well known physiological process e.g. germination, growth and reproduction. Ecesis is the most desire factor in invasion and migration without it, it is totally ineffective.
 4. **Reaction:** Between the colonizing plant species and the habitat causing change in habitat conditions of atmosphere and the soil e.g. area once fully lighted becomes more or less shaded (temperature becomes lower and the air is more humid); a wet area becomes drier for the migrants absorb large amounts of water from the soil which is lost through transpiration, water retaining capacity of a dry soil increases and it becomes richer by the accumulation of humus caused by decay of dead roots, stems, and leaves; the dry area gradually becomes more moist and certainly more favourable to plant growth
 5. **Competition:** As a result of ecesis, competition among different cloning species ultimately leading to the survival of the species, fittest or luckiest for that particular habitat
 6. **Stabilisation:** Achievement of complete emancipation and stability of the dominant species.
 7. **Climax:** Final formation of climax type forests.

Check your Progress

Note: a. Write your answer in the space given below

b. Compare your answer with those given at the end of the unit.

1. Define Food chain and Food web.
2. Differentiate between food chain and food web.

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2.9 LET US SUM UP

A food web consists of many food chains. A food chain only follows just one path as animals find food. E.g: A hawk eats a snake, which has eaten a frog, which has eaten a grasshopper, which has eaten grass.

A food web shows the many different paths plants and animals are connected.

The zone where two or more different communities meet and rate, is called transition zone or ecotone.

The total role of a species in the community is the ecological niche.

2.10 UNIT END EXERCISES

1. Explain the concept of food chain.
2. What are biomes?

2.11 ANSWER TO CHECK YOUR PROGRESS

1. Food Chain :The transfer of food energy from the source in plants through a series of organisms with eating and being eaten is referred to as 'food chain'

Food web: complex of interrelated food chains makes up a food web.

2. A food chain only follows just one path as animals find food. E.g: A hawk eats a snake, which has eaten a frog, which has eaten a grasshopper, which has eaten grass. A food web shows the many different paths plants and animals are connected. E.g: A hawk might also eat a mouse, a squirrel, a frog or some other animal. A food web is a graphical model depicting the many food chains linked together to show the feeding relationships of organisms in an ecosystem. It differs from a food chain in a way that the latter is a linear system showing a succession of organisms whereby each species is eaten in turn by another species

2.12 SUGGESTED READINGS

1. James P. Kimmins, 2003, Forest Ecology 3rd edition Benjamin Cummings Publisher. ISBN: 0130662585
2. Peter Stiling, 2001, Ecology- Theories and applications ISBN: 013091102X.
3. Jessica Gurevitch, 2006, The Ecology of Plants Sinauer Associates; 2nd edition ISBN:0878932941
4. Gary W. Barrett, Murray Barrick and Eugene Odum, 2005, Fundamental of Ecology, Cengage Learning, ISBN: 9788131500200

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UNIT - 3 POPULATION BIOLOGY

Structure

- 3.1 Introduction
- 3.2 Objectives
- 3.3 Population Biology
- 3.4 Population Survivorship Curves
- 3.5 Self – Regulating Mechanism
- 3.6 Let us sum up
- 3.7 Unit end Exercises
- 3.8 Answer to check your progress
- 3.9 Suggested readings

3.1 INTRODUCTION

A population is defined as a group of individuals of the same species living and interbreeding within a given area. Members of a population often rely on the same resources, are subject to similar environmental constraints, and depend on the availability of other members to persist over time. A species is a certain unique type or organism in the entire biosphere, while a population is all of the members of a species in one ecosystem or area.

The competitive exclusion principle, sometimes referred to as Gause's Law of competitive exclusion or just Gause's Law, states that two species that compete for the exact same resources cannot stably coexist. A survivorship curve is a graph showing the number or proportion of individuals surviving to each age for a given species or group (e.g. males or females). There are three types of survivorship curves and they are simply referred to as type I, type II, and type III. A type I survivorship curve shows individuals that have a high probability of surviving through early and middle life but have a rapid decline in the number of individuals surviving into late life.

3.2 OBJECTIVES

- To provide students with skills in Population biology- Basic concepts
- To instill in an appreciation for the Gause's principle, survivorship curves – self- regulating mechanisms.

3.3 POPULATION BIOLOGY

The term population biology has been interpreted in several ways, they are as follows

1. In human demography a population is a set of humans in a given area, such as village, town, city, state or country or even the world.

2. In Genetics, a population is a group of interbreeding individuals of the same species, which is isolated from other groups.
3. In ecology, a population is a group of individuals of the same species, inhabiting the same area, and functioning as a unit of biotic community.

For example, all individuals of the common grass snails or pine trees, of particular habitats, constitute their population.

Organisms in a population undergo the same life cycle. They experience similar ecological process at a particular stage of the life cycle.

Populations can be defined at various spatial scales. For example, local population can occupy very small habitat patches, like a temporary pond of water. A set of local population connected by dispersing individuals is called a Metapopulations.

Populations can also be considered at the scale of regions, islands, continents or oceans .Even the entire species can be treated as a population.

Characteristics of populations:A Population has a group characteristics, such as density, natality (birth rate), mortality (death rate), dispersal, age distribution (i.e., ratio of one age group to the other), biotic potential and growth forms.

Populations are group of individuals of the same species living in a particular place at the same time. They may differ in their number, patterns of living together, behavior and organization. All of these factors are important when considering the interactions of a populations with its environment and other populations. The description of a population involves several parameters such as (i) the number and kind of individuals of a species, (ii) a given space or an area, and (iii) time.

Density:

The number of individuals of a species living in a particular area is the density of population. Density is dependent upon many factors, such as danger of predators and the several availability of food, water, light, heat and nesting places. The density of a population increases when conditions are favourable to the populations and decreases when they are not favorable. Population density is determined by counting all the individuals and dividing it by the number of units of spaces. For terrestrial organism's usually two dimensional unit's m (a quadrate of 1m 1m) or soil surface are taken. For aquatic organisms and organisms suspended in a medium, space is expressed in three dimensions (m). If the total number of individuals is taken as N and the number of units of space as S, the population density D can be calculated as

$$D = N/S$$

For example, 50 individuals of a tree species may occur per hectare, or 70 individuals of the grass *cyndon* per square metre. Density

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of plants is determined by counting individuals in sample units of predetermined sizes. Species density varies from time to time and from one area to another. For human population, counting is being done every ten years.

Distribution:

The arrangement of the individuals of a population within a particular space is called the distribution. While population density gives us knowledge that how many individuals exist in an area, whereas the distribution tells us how those individuals are arranged in that area. The patterns of distribution are **random, uniform and clumped**. In random distribution organisms occur in no particular order. The organisms that are distributed in a uniform manner are spread evenly over an area, whereas the clumped organisms are concentrated at points throughout an area. Clusters may offer the population protection from enemies, wind and cold.

Factors Affecting Population:

Populations can change in many ways. They can get larger or smaller. The areas they occupy can increase or decrease. The ratio of males to females can vary. Changes in a population occur in response to some change in the factors that influence the population. A population tends to increase as individuals are added by **natality**, i.e., birth, hatching or germination, and **immigration**, i.e., moving in from outside. On the other hand, a population tends to decrease by **mortality** or death, and **emigration** or moving out. However, in the case of land plants incapable of locomotion, active immigration or emigration do not occur. An occasional addition to a plant population may occur through arrival of seeds from a long distance dispersed by air, water or animals.

Natality:

The increase in number of individuals in a population under given environmental conditions is called natality. For example, birth, hatching, germination and vegetative propagation are main causes which are responsible for increase of number of individuals.

When the increase in individuals is expressed per unit time, it is called, **natality rate**.

Natality is calculated as follows:

Birth rate or natality (B) = number of births per unit time / average population

The maximum number of births produced per individual under ideal conditions of environment is called potential natality.

Natality varies from organism to organism. It depends upon the population density and environmental factors. It is a general rule that if the population density is low, the birth rate is also low, because the chances of mating between males and females are low. On the other hand, if population density is unusually high, the birth rate may also be

low due to poor nutrition, or physiological or other problems related to crowding.

The maximum or absolute natality is observed when the species exists under ideal ecological and genetic conditions. The actual number of births occurring under the existing environmental condition is much less as compared to absolute natality. It is referred to as **ecological natality** or realised **natality**. It is not constant for population and may vary with the size of population as well as with the time.

Mortality: The loss of individuals due to death in a population under given environmental conditions is called mortality.

Mortality refers to the number of deaths per unit time.

Mortality rate = D/t where D is the number of deaths in the time t

Mortality can be expressed as follows:

- (i) **Minimum or specific or potential mortality:** It represents the minimum or theoretical loss of individuals under ideal or non-limiting conditions. Thus even under the best conditions individuals of a population would die of old age determined by their physiological longevity. So it is constant for a population.
- (ii) **Ecological or realised mortality:** It refers to the death of individuals of a population under existing environmental conditions. Since it varies with environmental conditions, it is never constant. The maximum mortality occurs at the egg, larval, seedling and old age.

Mortality is affected by a number of factors, such as density, competition, disease, predation and environment. Death rates vary among the species and are correlated with birth rates. When the rate of natality is equal to the rate of mortality, the population is stationary.

A birth-death ratio (births/deaths * 100) is called **vital index**.

For a population, the survival of individuals is more important than the death. The number of births in relation to the carrying capacity of the habitat is a fundamental factor influencing mortality rate. When more Youngs are born than the habitat can support, the surplus must either die or leave the area. As the number of survivors is more important than the number of individuals, mortality is better expressed as survival or as **life expectancy**. The life expectancy refers to the average number of years the members of population have left to live.

Dispersal: The majority of organisms disperse at one time or the other during their cycles. The individuals move into (immigration) and move out of the population (emigration), and such movements affect the size of population.

Movement of individuals into and out of the population is called **population dispersal**. It plays important role in the geographical distribution of organisms even to the areas previously occupied by the members of population. Dispersal of organisms occurs for various reasons such as food, protection, prevention from overcrowding, action

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of wind and water, environmental factors such as light, temperature, breeding behaviour, and physiological reasons of for interchange of materials between the populations.

Population dispersal occurs in nature as follows:

- (i) **Emigration:** It is one way movement of individuals out of a population. This movement is permanent and causes spread of a species to new areas. Emigration under natural conditions occurs when there is overcrowding in the population and is generally regarded as an adaptive behaviour that regulates the population on a particular site and prevents over-exploitation of the habitat. This type of dispersal offers new opportunity to the individuals of a population to interbreed with those of the other population leading to more genetic heterozygosity and adaptability.
- (ii) **Immigration.** This is one way movement of individuals into a population. It leads to rise in density of population. It may result in decreased mortality among the immigrants or decreased reproductive capacity of the individuals
- (iii) **Migration.** Migration is two way mass movement of the entire population. It involves a periodic departure and return of the individuals of a population and occurs only in mobile organisms during unfavourable periods. It is shown by many birds, fishes and certain animals. In most cases migration of population occurs for food, shelter or reproduction.

Age distribution:

Age distribution is an important characteristic of population which influences natality and mortality. Mortality, usually varies with age, as changes of death are more in early and later periods of life span. Similarly, natality is restricted to certain age-groups e.g. in middle age-groups higher animals.

The individuals of a population can be divided in three ecological stages. They are: (i) **pre-reproductive**, (ii) **reproductive**, (iii) **post-reproductive**. The individuals of pre-reproductive group are young, those of reproductive group are mature and those in post-reproductive group are old.

The distribution of ages may be constant or variable. It is directly related to the growth rate of the population. Depending upon the proportion of the three age groups can be said to be **growing mature or stable, and diminishing**. Rapidly increasing population contains a large proportion of young individuals, a stable population shows even distribution of individuals in reproductive age group, and declining or diminishing population contains a large proportions of old individuals.

Age pyramids:

Age pyramid a model in which the numbers or proportions of individuals in various age groups at any given time are geometrically presented. In an age pyramid, the number of pre-reproductive

individuals is shown at the base that of reproductive age group in the middle and the number of post-reproductive individuals at the top. The age pyramid indicates whether a population is expanding or stable or diminishing. The hypothetical age pyramids are as follows:

(i) **Pyramid with broad base.** This pyramid shows a high percentage of young individuals and an exponential growth of population due to high birth rate, e.g. yeast, housefly, etc.

(ii) **Bell-shaped pyramid.** This type of age pyramid shows a stable population having, more or less equal number of young and middle-aged individuals and post-reproductive individuals and post-reproductive individuals being in smallest number.

(iii) **Pyramid with narrow base:** This is an urn-shaped pyramid which shows increased numbers of middle-aged and old organisms as compared to young ones in the populations. This shows diminishing of populations.

Biotic potential and environmental resistance:

Every kind of organism produces more offspring than are necessary for that species to survive. The maximum reproduction rate of a population under ideal conditions called biotic potential. This factor assumes that all of the young will live long enough to reproduce. To reach its biotic potential a population must have all of the food or raw materials, water and space it needs to survive. It also needs an ideal climate and the absence of competitors and disease. For instance, some bacteria divide about every 20 minutes. In 24 hours, the number of individuals produced would be enough to cover the entire surface of the earth to a depth of over 20 cm. However, populations do not reach their biotic potential. Many factors influence the growth rate of population.

Environmental resistance means the collections of factors that reduce the growth rate of a population.

Biotic and abiotic factors influencing population growth:

Biotic factors that influence population growth are living organisms or their characteristics. For example, the biotic factors that influence a population are the presence of predators or hunters, the food supply, the density of the population itself, the biotic potential of the species and disease. Abiotic factors are nonliving physical elements in the environment such as temperature, water, humidity, light, soil, slope, air and wind.

Density dependent and density independent factors:

Density dependent factors influence a population differently if the population is crowded than if it is not crowded. The effects predators, disease and competition vary with the concentration of the population. For example, a disease spreads more rapidly through a crowded population severely. The biotic factors influence all population than through a sparse one. The loss of a food source affects a crowded population, regardless of their density, and are called **density-independent**. For example, a forest fire affects the food supply and shelter of all organisms in the areas whether they are crowded or not crowded.

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3.4 POPULATION SURVIVORSHIP CURVES

The growth is one of the dynamic features of species population. Population size in a characteristic way. The growth of a population can be measured as increase in its size over a period of time. The change in population size may be expressed as follows:

Population having initial size, N_0

Population increases to size, N_t , and Time interval, t

$$N_t = N_0 + B - D - E$$

Here, N_0 = size of population at the beginning of change

B - Natality rate

I - Rate of immigration, i.e., individuals coming in

D - Mortality rate

E - Rate of emigration, i.e., individual moving out

When the number of individuals of population is plotted on the y-axis, and the time on the x-axis a Curve is obtained that indicates the trend in the growth of population size in a given time. This curve is called **population growth curve**. There are two types of growth curves:

(i) J-shaped curve. In the case of J-shaped growth form, the population grows exponentially, and after attaining the peak value, the population may abruptly crash. This increase in population is continued till large amount of food materials exist in the habitat. After some time, due to increase the population size, food supply in the habitat becomes limited which ultimately results in decrease in population size. For example, many insect populations show explosive increase in numbers during the rainy season, followed by their disappearance at the end of the season.

The following equation exhibits J-shaped growth:

$$\frac{dN}{dt} = rN$$

Here dN/dt represents rate of change in population size, r is biotic potential and N stands for population size

(ii) S-shaped or sigmoid curve: When a few organisms are introduced in an area the population increase is very slow in the beginning, i.e., **positive acceleration phase or lag phase**, in the middle phase, the population increase becomes very rapid, i.e., logarithmic phase, and finally in the last phase the population increase is slowed down, i.e., **negative acceleration phase**, until an equilibrium is attained around which the population size fluctuates according to variability of environment. The level beyond which no major increase can occur is referred to as **saturation level or carrying capacity (K)**. In the last phase the new organisms are almost equal to the number of dying individuals and thus there is no more increase in population size.

The S-shaped sigmoid growth form is represented by the following equation:

$$\frac{dN}{dt} = rN \left(\frac{K-N}{K} \right) = rN \left(1 - \frac{N}{K} \right)$$

Where, dN/dt is the rate of change in population size

r is biotic potential

N is population size

$K-NIK$ or $1-(N/K)$ is for environmental resistance

Human Population:

The distribution of human population in various regions of the world has been and is quite uneven in terms of its density mainly because of geographical, socio-economic and demographic factors. Only about thirty per cent of the world's land area is inhabited by man.

The pattern of human population and population growth depend upon several factors such as – (1) geographical factors like climate, location of water, soil, energy, mineral resources, transportation etc., (2) socio-economic factors, and (3) demographic factors

Geographical factors:

The north and south poles are free of human habitation mainly because they are extremely cold and also agriculturally unproductive. Human settlements occur in places where adequate source of water are available. The fertility of the soil for farming is another important determinant of population distributions. For instance, the main basis of the highly dense populations in the Indus valley and Indo-Gangetic plains is the alluvial nature of the soils in these regions.

In certain places both iron ore and coal and other fossil energy sources are located close together. Industrial cities based around steel plants have come up in Jamshedpur, Bokaro, Durgapur, Bhilai and Rourkela.

Means of transportation have played an important role in the redistribution of populations. This made it possible for the first time for persons to live far away from the source of produce or of goods required for living. Transportation by water is cheaper than by land or air and this is probably the main basis for the coastal location of most big cities such as Kolkata, Mumbai, London, New York and Tokyo.

Socio-economic factors:

The size of population, and birth and death rates have great significance on the standard of living of the people, their aspirations, and their economic and social development. The birth rate of human population is regulated more by socio-economic factors than biological factors. These factors may be social status of women, age of women at marriage, family structure, education, acceptability of family planning practices, and religious beliefs.

Prosperity in the cities is the basic cause of continued urban growth. Some important consequences of increasing urbanization are overcrowding. Leading to problems of sanitation and sewage disposal; transportation and associated traffic problems; environmental pollution by industrial activities and automobiles; noise pollution and various socio-economic and cultural changes and problems related to juvenile delinquency and crime. Urbanization involves progressive increase in the

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use of our fertile agricultural lands for housing new industries factories, government offices, schools, hospitals and residential quarters.

Demographic factors:

The birth-rate, death-rate, and the rate of natural increase are called vital rates because any change in these parameters will determine the overall pattern of population density. The study of trends in human population growth and the prediction of future development makes a special branch of knowledge called **demography**. Such studies involve parameters that is the number, and proportion of different age-groups requiring education, training and employment. Countries with a wide gap between birth rate and death rate tend to have a population age structure in which a higher percentage of its population consists of pre-school and school-going rate of a narrow gap between birth and death rates would contain relatively much lower proportion of pre-school and school-going age groups. Data of age distribution and economic status of different social groups are also needed for economic and social welfare planning.

The human population is increasing at an enormous rate. However, the rate of growth is not uniform in all countries. It may vary even in different groups of the same country. Unlimited population growth leads to over-crowding, has adverse environmental implications, especially in urban areas. It tends to reduce food, water, fuel, land and other natural resources. It is a fact that the growth of human population is more stable in the developed countries, i.e., both the birth rates and death rates low. When the birth rate of a population is high the population increases and other hand when the death rate is high the population has decreases. IN the United States of America, France and Germany, the population growth is more stable than in developing countries like Pakistan, Bangladesh, India and China. Usually, the relationship between population the level of industrial development and education is inversely proportional. Such relationship is also found among different groups of the people in the same country.

Species, Ecological Interdependence and Interactions

The individual organism is a distinct package carrying out life processes within its body as an entity separate from those being performed in the bodies of other. The organisms may be unicellular or multicellular. The example of individual organisms are potato plants, bean plants, cat, rats, tigers and others. Such organisms can be counted, measured and studied. However, in many cases they remain organically connected with one another such as in grasses o in colonies of corals and sponges. The individual's organisms always develop from pre-existing ones by means reproduction which may be vegetative, asexual or sexual.

Species:

A large variety and numerous individual organisms are found in nature. The organisms do not occur in isolation. Such organisms may be

of a kind as cats, rats, tiger, bean plants, humans, etc. The individual organisms aggregate and form population. A geographically localised group of individuals of the same kind form a species. The individual organisms of a species may differ in structure and function depending upon their sex, stage of development or specialisation for specific. For example, in many insects the adult, larval and pupal stages are considerably different in frogs, toads and salamanders the adults and larval stages are quite different in structure and function.

On the other hand, in many organisms the males and females are different in size, form and colour. When two forms occur among the organisms of the same kind the phenomenon is called **dimorphism**. The horse and the mare, the dog and the bitch, the lion and the lioness, man and woman, peacock and peahen are not alike. They exhibit **sexual dimorphism**. Plants such as the date palm and cycas have male and female individuals and bear different types of flowers and sporophylls.

The individuals in a colony of honey bees and termites differ considerably in structure and function. When many forms of individuals occur with the same kind of organisms the phenomenon is called **polymorphism**. Various types of individuals occur in some coelenterate colonies. For example, a colony of Physalia is made up hundreds of individuals of different kinds comprising feeding, protective, reproductive and float forming individuals. A colonial form of Volvox (a green algae) consist of about 60,000 or more cells. In such colony only the peripheral cells bear flagella, and help in locomotion. A few cells are reproductive, and the larger part of the colony is made of vegetative cells. Many wild species of flowers show colour polymorphism. To some extent polymorphism helps in survival and adaptation of species.

Within a species there are some populations which show some morphological characteristics. For instance in South Africa the people of Zulu tribe are short statured (i.e., 1.2m) and those of Watusi tribe are tall (i.e., 2.2 m). The different human races show considerable physical differences. The negroids, caucasoids and mongolioids, can be recognized by their peculiar faces. Similarly, the various breeds of dogs, cows, sheep, roses and other cultivated plants look quite different in size, colour and appearance. For example, there are several such as Keeshond, Eskimo, Cairns terrier, Indian greyhound Welsh terrier, Chow, Dachshund, Dalmatian, Irish terrier, Yorkshire terrier, Bulldog and Irish wolfhound which are quite in size colour and apperance. However all these different looking individuals of the same species may interbreed among themselves? While the populations or individuals belonging to different species may appear quite similar but do not breed in natural conditions.

Thus a species can be defined as a group of closely related, structurally and functionally similar organisms which interbreed with one another in nature, but not with organisms of other groups.

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The inability to interbreed or reproductive isolation makes the most important distinction between different species. Thus, reproductive isolation is the of different species. But there are several examples of two species are alike and still do not interbreed. However, members of two different species may breed under captivity or under artificial conditions. As we know, the horses and donkeys are of distinct species but they interbreed and produce sterile offspring, the **mule** (i.e. progeny of male donkey and mare) or hinny (i.e., progeny of stallion and female donkey). The artificially produced hybrids between bull frogs leopard fog die before reproductive age. There are some examples of species that interbreed under captivity to produce fertile offspring, they are- the platy and swordtail fishes. The interbreeding between members of two different species the platy and are-the isolating condition is removed artificially. There is great diversity in the living world. To study the diversity, the scientists have developed several hierarchical terms-many similar species make a **genus** many related genera constitute a **family**, and several related families form the **order**

Origin of Species:

It has already been mentioned in the preceding paragraphs that prevention of interbreeding between members of different species is essential for the maintenance of identity of the species. It is an established fact that life arises only from pre-existing life. It is also thought, that new species is derived from the par-existing ancestral species. Now the question arises, how does a new species originate. Here, we will consider the origin of a terrestrial species which has a wide range of distribution. For example, due to development of a physical barrier, such as a high mountain range large body of water, it becomes impossible to maintain interbreeding between the members of groups thus separated. Sometimes the long distance between populations may act as a reproductive barrier between them. In the initial stages, interbreeding between the individuals of these two populations will be possible if the isolation factor is artificially removed. However, the absence of a reproductive contact for a long time will lead to a loss of capacity for interbreeding. In the due course of time, the individuals of these populations undergo physical and physiological changes depending upon their environment, so that, they become morphologically different from each other. They would gradually go away from each other in structure and function and ways of living and become as different as to give rise to a new species.

Interaction between Members of a species:

The individuals of a species interact with each other in several ways, such as cooperation, communication and competition.

Cooperative interaction:

This type of interaction is essential for reproduction and perpetuation of the species. Organized social interactions offer the

advantages of cooperation in reproduction, caring for the young, obtaining food and in defence. A herd of musk oxen form a circle for protection. Social organization may be very simple or very complex. The simplest social behaviour is herding, schooling or flocking. The individuals are less likely to be captured by a predator while in a school than if alone. Social organization also aids in reproduction and rearing. For the seal, meeting at the breeding area makes contact between male and female easier. The baboons and monkeys live together for such advantages as grooming each other and caring for the young. Herding, rank establishment and territory and other interactions are restricted to certain animals only.

Group formation:

Family life or group formation in different animals varies. It is found only in few types of animals. Foxes, wolves and swans are monogamous, i.e., once a male and female come together the partnership last throughout life. However, in sparrow the partnership breaks down at the end of a breeding season, and the male and female birds find new partners in the subsequent years. Seals, walrus and deers are **polygamous**. A male keeps a harem of many females. Rats, mice and some other animals do not have any fixed partners.

Many animals, such as geese, ducks, parrots, antelopes, deer, zebras, elephants and monkeys live in groups or herds. Members of each herd cooperate for mutual protection and finding food and water for the herd. For example, it has been observed in the Bandipur Sanctuary of Karnataka that when a group of cheetals is attacked by predator, such as the wild dog, panther or tiger, the live destruction. This is a unique example of the self-sacrifice of a few individuals' deer allowing themselves to be killed in the interest of the species.

Usually a community has a few populations that are more important in determining the nature of community of than the others. These **dominant species** strongly influence the food supply and the environment of the other species. In a forest, the large trees are usually dominant trees are dominant species. Large trees dominate forests because their canopy of leaves over the other populations determines how much light is available to other plants.

On the other hand, within the herd there is a social organisation and ranking of individuals. Usually the females are subordinate to males and the young are subordinate to the adult. In the red deer the female is the leader of the herd. **Dominance** or ranking of individuals is generally settled by battles. Dominance is also established by an aggressive posture or display of feathers by birds. In most species, the individuals of the highest rank has the first choice of mate and food followed by individuals of subsequent ranks.

The honey bees, ants and termites form well organised societies having division of labour among its members showing **polymorphism**. In these social insects (honey bees) the individuals of different kinds (i.e.,

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polymorphic) live together in a colony and work together for the benefit of the group. Here the insect societies are formed of different castes such as workers, males (drones) and queen. All of them are specialized for different kinds of work. The workers collect and store food. They also build houses of complicated design, and also do other special tasks. The males and the queen are mainly involved in reproduction and act as the progenitors of future colony.

In the termites incomplete metamorphosis is found, which shows that the insects hatched from eggs are very similar to adults and develop into adults through growth and moulting. Most of these function as worker termites, and have perpetual adolescent phase and do not develop into adults. Only the **king** and the **queen** reach the adulthood and produce future colony through sexual reproduction.

The insect societies are quite different from the human society. They differ both in origin and organisation. Human societies show more psychosocial evolution than biological evolution. The members are made of numerous family units composed of males and females, adults and juveniles. However, the insect societies are the products of biological evolution based on learnt behavior. All the members of the colony are derived from common parents.

3.5 SELF – REGULATING MECHANISM

Individuals, pairs or groups of vertebrates, invertebrates, commonly restrict their activities to a definite area. This area over which the animals wander in search of food and mates, is called their **home range**. Variations in home range is associated with the species, sex, age, season and with such ecological condition as availability of food, shelter and intraspecific struggle. Home range provides an animal with its necessities of life, such as food, cover, shelter and to rear young ones.

A number of breeding groups that is pairs and herds inhabit a home range. Each breeding group, or an individual occupies a particular **territory**. The home range of different groups can overlap but not the territory. Each territory centers round the individuals or group`s home, nests, holes, burrow, or other types of shelter. The special odours of the urine or faeces delineate the territory of animals like dogs and tiger. The territory is defended by its members. The territorial concept is most developed in birds where the male first establishes a territory. It drives off all other males of the same species from this territory and sometimes also females other than its mate.

Communication: The survival and well-being of animal population is largely dependent upon the communication among the members of the population. Even simple organisms have developed methods of communication, such as sight, sound, chemicals or contact. Through these methods of communication, members of a population indicate

dominance, submission, the source of food, the presence of danger, hunger, the urge to mate, and the limits of territory.

Visual displays:

Animals may use visual displays to communicate. This is the way where the animal stands, moves, or shows body colouring. For example, an aggressive cobra arches its back, bares its fangs, and displays the neck hood. Male birds are often brightly coloured to attract females of their species and to draw the attention of enemies away from the females and young. Honey bees perform various dance movements to indicate the distance and direction of the food source.

Communicating by sound:

Animals may also communicate by making sounds. Each call or cry carries its own special message. Some animals have as many as two dozen different sound signals indicating hunger, fear, threat, annoyance, desire for mating and parental concern. Even animals such as rabbits and giraffes, utter sounds when they are intensely afraid.

Use of chemicals:

Certain special chemical compounds such as pheromones, secreted by animals transmit message to other members of the species. Pheromones are detected by smell or taste. These chemicals communicate territorial rights, fear, or a desire to mate. The territory making compounds in urine and faeces as already mentioned in preceding paragraphs are also pheromones. Ants release chemicals containing pheromones, which enable the members of colony to find their path from the colony to the source of food and back. The sex pheromones are used by bitch during the breeding season to attract the male dog. A dog can smell a bitch from a distance of one kilometer.

Chemicals can also be produced and secreted by **specialized glands** or **tissues** and may be included in the urine or saliva. The male lion marks his territory by spraying urine at points along the outer edge of his territory. Among social animals, the dominant males have large **scent-marking glands** as compared to the others on the group and use them more often.

Physical contact:

To convey concern, hunger, play or aggression, animals may use physical contact. A young bird pecks at the parent's bill to communicate hunger. A pet cat will rub up against a person to communicate pleasure. Giraffes use their long necks in struggles for dominance by knocking heads and necks.

Competition:

The amount of food, light, space, minerals and water that are available in a particular habitat is limited. With another for one or more of these factors. Competition can be defined as rivalry between two or more organisms for obtaining the same resources. For example, sparrows

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fight with each other for shelter, and wall lizards chase each other to catch insects. Populations may compete directly, leading to the extinction or adaptation of one of them.

Plants also compete for space, light, water and minerals. The dense mass of seedlings compete among themselves. Some seedlings grow faster than the others and survive, others remain weak and eventually die. However, proper seed dispersal reduces the competition. In some xerophytic plants the roots secrete certain compounds which inhibit the germination of seeds within a certain distance. The many interactions among the members of a species, such as group formation, territorial maintenance, communication and competition have a common function and that is survival of species.

Species Interdependence:

Members of the biotic community in an area are dependent on each other. The interdependence is usually observed in their interaction, mainly for food, space, reproduction protection. Such interactions are important for survival of different species and the biotic community as a group. Food interactions are reflected in food chains, which consist of plants, animals and microbes.

Plants and animals have well established interdependence for reproduction. For example: insects are flower-specific and have structures suitable for nectar sucking and pollination.

Contrary to it, some flowers are insect-specific. For example, snapdragon flower possesses lip-like petals which facilitate insect entry and landing. Here, both flowers and insects have developed and evolved in a way leading to their interdependence. The nectar of flowers is main attractions for insects. Insects visit the flowers in search of nectar and pollination is affected. The fluctuations in insect pollination would affect pollination that leads to plant reproduction.

Birds and mammals help in the dispersal of seeds and fruits. Interdependence may also be shown by certain other specific examples. For example, cuckoo lays eggs in the nest of other birds, gall wasps bury their eggs deep into the tissues of plants that ensure hatching and protection.

Camouflage:

Some members of biotic community, particularly animals, sometimes Camouflage to avoid detection. For example, butterflies and moths have colours which match the colours of flowers, and therefore, their detection becomes difficult. The camouflage can be observed in praying mantis and leaf insect, which mimic the shapes of leaves and branches

Mimicry:

For example, orchid's mimicry the butterfly, as their colours are concerned. Generally, weaker members of animals, mimic the strong, fast moving species and which have a fewer natural enemies. For example,

non-poisonous snakes mimic the poisonous snakes to avoid enemies. Usually, birds mimic voice of other animals.

Check your progress-1

Note: a. Write your answer in the space given below
b. Compare your answer with those given at the end of the unit.

1. Write a short note on natality
2. Explain J shaped pattern of population

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3.6 LET US SUM UP

Ecological succession is the process of change in the species structure of an ecological community over time. A population refers to a group of organisms of a species that interbreed and live in the same place at a same time. They are capable of interbreeding or reproduction. Interaction species refers to positive and negative associations between species that favour or inhibit mutual growth and evolution of populations. It may take the form of competition, predation, parasitism, commensalism or mutualism.

3.7 UNIT END EXERCISES

1. What is Population?
2. Differentiate Polymorphism and Dimorphism.

3.8 ANSWER TO CHECK YOUR PROGRESS

1. The increase in number of individuals in a population under given environmental conditions is called natality.
2. **J-shaped curve.** In the case of J-shaped growth form, the population grows exponentially, and after attaining the peak value, the population may abruptly crash. This increase in population is continued till large amount of food materials exist in the habitat.

3.9 SUGGESTED READINGS

1. James P. Kimmins, 2003, Forest Ecology 3rd edition Benjamin Cummings Publisher. ISBN: 0130662585
2. Peter Stiling, 2001, Ecology- Theories and applications ISBN: 013091102X.
3. Jessica Gurevitch, 2006, The Ecology of Plants Sinauer Associates; 2nd edition ISBN:0878932941
4. Gary W. Barrett, Murray Barrick and Eugene Odum, 2005, Fundamental of Ecology, Cengage Learning, ISBN: 9788131500200

UNIT-4 SPECIES INTERACTION

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Structure

- 4.1 Introduction
- 4.2 Objectives
- 4.3 Evolution of cooperation
- 4.4 Species Interaction of Living organisms with Environment
- 4.5 Negative interaction
- 4.6 Positive interaction
- 4.7 Let us Sum up
- 4.8 Unit – End Exercises
- 4.9 Answer to Check your Progress
- 4.10 Suggested Readings

4.1 INTRODUCTION

Stabilizing mechanisms promote coexistence by concentrating intraspecific competition relative to interspecific competition. Resource partitioning, whereby interspecific competition is reduced because species compete primarily through different resources, is a stabilizing mechanism. Intra species competition occurs among the members of the same species while, interspecies occurs among the organisms who belong to different species. As; requirements of members of same species are almost same hence; the struggle among them is more complicated than interspecies competition

In negative interactions, one of the interacting populations is benefited and the other is harmed. In negative interaction one population may eat members of the other population, compete for foods or excrete harmful wasters. Different types of negative population interactions. Predation is the act of preying on someone or something, especially when you're talking about animals. Nature shows can be hard to watch when they show the predation of an animal on a smaller, cuter animal. A predator is an animal that attacks a smaller, weaker animal, called the prey. Herbivores may eat any part of the plant above the soil including leaves, stems, flowers, fruit and any part of the plant below the soil including roots and tubers. Lace bug (Tingidae) upside down, sucking fluid from a hairy stem. Parasitism is a relationship between species, where one organism, the parasite, lives on or in another organism, the host, causing it some harm, and is adapted structurally to this way of life.

In positive interactions, the interacting populations help one another. The positive interaction may be in one way or reciprocal. The benefit may be in respect of food, shelter, substratum or transportation. The positive association may be continuous, transitory, obligate or

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facultative. Commensalism, in biology, a relationship between individuals of two species in which one species obtains food or other benefits from the other without either harming or benefiting the latter. Mutualism is defined as an interaction between individuals of different species that results in positive (beneficial) effects on per capita reproduction and/or survival of the interacting populations.

4.2 OBJECTIVES

- To provide students with skills necessary for Species interaction - evolution of cooperation, inter-specific competition, competition coexistence-
- To instill in students an appreciation for the complexity of Negative interaction- predation, herbivory, parasitism - Positive interaction - commensalisms and mutualism.

4.3 EVOLUTION OF COOPERATION

Cooperation is one of the great developments in evolution. Once creatures could learn to work together, then they significantly increased their ability to survive. From hunting together to shared protection of young, there are many benefits.

In evolution, co-operation is the process where groups of organisms work or act together for common or mutual benefits. It is commonly defined as any adaptation that has evolved, at least in part, to increase the reproductive success of the actor's social partners. For example, territorial choruses by male lions discourage intruders and are likely to benefit all contributors.

This process contrasts with intragroup competition where individuals work against each other for selfish reasons. Cooperation exists not only in humans but in other animals as well. The diversity of taxa that exhibits cooperation is quite large, ranging from zebra herds to pied babblers to African elephants. Many animal and plant species cooperate with both members of their own species and with members of other species.

4.3.1. Direct reciprocity

Direct reciprocity is an immediate collaborative exchange that benefits everyone, such as in hunting together where one drives the animal towards another who kills it so both can then eat.

The reciprocal arrangement is typically one-for-one. I do something for you and you do something for me. There is little in the way of negotiation and the exchange is simple.

A common direct reciprocity is 'tit for tat' (colloquial for this for that) where I copy what you do, being helpful or unhelpful. This is a reasonable strategy when you do not know the intent of other side. Before long, you learn that you will lose out if you betray me. The problem with this is that forgiveness is not included and it is easy to fall

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into a negative pattern.

There is immediate and obvious benefit from direct reciprocity and there is relatively little need for trust into the future. Trust is a critical question and is almost always lost at some time. Forgiveness is hence critical to allow for new opportunities in collaboration.

4.3.2. Indirect reciprocity

Indirect reciprocity is where there is a separation between contribution and gaining benefits from others. Such as caring for the young of others who are out hunting for food.

The complexity of indirect reciprocity means that this is more appropriate where species have a greater ability to reason, which limits any sophistication in this activity to humans (although some people still do not get it).

Indirect reciprocity requires greater trust as there is more potential for one party to betray the other and get away with it. This is facilitated by *reputation*, which needs a language by which an individual's trustworthiness can be communicated.

4.3.3. Spatial selection

Spatial selection is a principle used by individuals and groups who live in protected areas where they are immune from attack by predators. The basic idea of this is that if they can find a safe place, then they will be more likely to survive. The stability and security also means that they are more likely to have more children, which then grows the population faster.

In this spatial heterogeneity it is important that people do not leave the tribe. By staying and working together for the greater good, each individual has a better chance of survival. This becomes even more true when there is conflict between tribes as the larger tribes have a greater chance of winning.

A growing population will need to expand its territory. Humans have done this right across the world. By living and working in cooperative tribes, they have spread to every corner of the globe, even where insects cannot survive.

Spatial selection also happens in the social divisions within society. People with similar amounts of money and status tend to live in the same areas, become friends and intermarry.

4.3.4. Groups selection

Warfare is a natural result of spatial selection where individual groups or tribes start expanding and so fall into conflict with nearby tribes as they fight for land rights, from hunting to water access to outright exclusive ownership.

The principles of individual selection now apply to groups. Those who can mutate and adapt better than others can drive away, enslave or kill their competitors, taking their land in the process.

In warfare, extreme collaboration is needed, fighting alongside your colleagues and being prepared to lay down one's life for the greater

good of the tribe.

The same principle applies to companies, where groups of people fight for a limited supply of customers, collaborating and working hard together for group success (and hence individual success).

4.3.5. Kin selection

Kin selection starts with the choice of a mate. If you have a better choice when looking for a mate, then, provided you are good at choosing, you will be more likely to find a mate who is fertile and comes with associated power, such as a successful family.

It continues with our clear support of those to whom we are related over non-relatives. We will incur cost to support our kin, who carry the same genes as us. We even give more weight to closer relatives, whose genes are more similar to ours. Kin hence tend to support one another also and there are often very strong obligations to do so (hence sayings such as 'blood is thicker than water'). Evolutionary biologist J. B. S. Haldane summed it up when he said "I will jump into the river to save two brothers or eight cousins."

Kin pass genes on to one another. Hence more successful people are more likely to have more successful children. This also applies to non-genetic factors such as having money and status to lavish on your children.

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4.4 SPECIES INTERACTION OF LIVING ORGANISMS WITH ENVIRONMENT

In a natural environment, living organism (i.e. flora; plants of particular area, fauna; animals of a particular area) live together influencing each other's life directly or indirectly.

Odum (1971) divided the interaction into two major groups as follows

4.5 NEGATIVE INTERACTION (i.e. Antagonism):

(i) **Competition:** When a species, in association of two or more species, is adversely affected by other species in respect of shelter, food, space, light etc., the phenomenon is termed Competition. It is of two types as follows:

(a) **Intraspecific competition:** In this case, competition occurs between the individual of same species having common requirements, e.g. large fishes feed on small fishes

(b) **Interspecific competition:** In this case competition occurs between individual of different species for common materials and conditions, eg fishes eating zooplankton, carnivores feeding on herbivores etc.

(ii) **Predation:** In this case, one species (i.e. predator) kills and feed on second species (i.e. prey. Predation Is Important process in the

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community dynamism. It represents a direct and complex interaction between two species of eaters and eaten.

(iii) **Cannibalism:** In this case, bigger individual's kills and feed on the small one of same species, It is very common in insects like ants, termites, cockroaches etc. It is also found in fishes, amphibians and reptiles.

(iv) **Parasitism:** When two organisms live together in which one derives nourishment at the expense of the other the condition is called parasitism. In the parasitic association, the species which provides nourishment and support, is called host and the one which get support and nourishment is called the parasites.

(v) **Antibiosis:** In this case, substance produced by an organism is harmful to others. Fungi produces some antibiotic (e.g. aureomycin, penicillin, streptomycin etc.) which destroys the various pathogenic bacteria.

(vi) **Amensalism:** In this case of interaction between the two species, one species is harmed or inhibited and other is neither benefited nor harmed by the association. Green algae (*Chlorella vulgaris*) produces chlorellin which is toxic to other species of algae

4.6. POSITIVE INTERACTION

It is beneficial to the participant and it not harmful of any one of the species. It is of different types et the rs e.g as follows

(i) **Neutralism:** When the presence of one species appears to have no effect on the second species (i.e. no Interaction), it is state of *neutralism*.

(ii) **Mutualism:** Here both the species are mutually befitted in different ways as follows:

(a) **Lichens:** Mutualism is best demonstrated in lichens. The lichen is composed of two components Le. Algae and fungus. The fungus support the algae and the algae supplies food to the fungus

(b) **Pollination by insects:** Bees, moth, butterflies etc., collect their food from nectar or other aromatic products in flowers of some plant and in return bring about pollination.

(c) **Dispersal of fruits and seeds:** The bird, bats and other animals eat the fruits and seeds contain in them are dropped in the excrement at different places, in this way, they help in the dispersal fruits and seeds.

(d) **Mutualism between plants and animals:** Unicellular green algae (*Chlorella vulgaris*) lives within the gastrodermal cells of hydra. The algae provides foods and oxygen to hydra and the algae in return get shelter, nitrogenous wastes and carbon dioxide.

(e) **Symbiotic nitrogen fixers:** The bacteria (e.g. *Rhizobium* etc.) lives in nodule of leguminous plant such as dhaincha (*Sesbania aculata*), sannhemp (*Crotalaria juncea*), pulse crop (i.e.cowpea-*Vigna catiang*, pea-*Pisum sativum*, khesari- *Lathyrus satiuus*, lentil-*Lens esculents*, soybean - *Glycine max*, etc.), berseem (*Trifolium alexandrium*), lucern

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(*Medicago sativa*) etc. Bacteria receives carbohydrate and other substances from the juice of the host (i.e leguminous plant) and the host plant get nitrogen fixed by the bacteria

(iii) **Colonization:** Colonial life is observed in various groups of animal, Parental care is found in female earwing, male stickle backs, many of the amphibian, reptiles, mammals and birds

(iv) **Aggregation:** Some animals remain in aggregation and it has some survival significance, Social life is exhibited in some tent caterpillar (e.g. *Malacosum*), ants, termites etc.

(v) **Social organization:** Social organization is found in some animals such as bees, ants, termites, wraps etc., and there is a division of labours among the individuals in the population. It is very important mechanism in the regulation of population density.

Check your progress -1

Note: a. Write your answer in the space given below

b. Compare your answer with those given at the end of the unit.

1. What is mutualism?
2. What is parasitism? Give suitable examples

4.7 LET US SUM UP

In this unit you have learnt about basic concept related to the environment and ecology, it also discuss with food chain, food web, ecological succession, population biology and species interaction. Environment is the sum total of all conditions and influences that affect the development and life of all organisms on earth. Ecology is the branch of science that deals with the study of interactions between living organisms and their physical environment. A food web consists of many food chains. A food chain only follows just one path as animals find food. E.g: A hawk eats a snake, which has eaten a frog, which has eaten a grasshopper, which has eaten grass. A food web shows the many different paths plants and animals are connected. Ecological succession is the process of change in the species structure of an ecological community over time. A population refers to a group of organisms of a species that interbreed and live in the same place at a same time. They are capable of interbreeding or reproduction. Interaction species refers to positive and negative associations between species that favour or inhibit mutual growth and evolution of populations. It may take the form of competition, predation, parasitism, commensalism or mutualism.

4.8 UNIT- END EXERCISES

1. Write notes on commensalism with one suitable example
2. Explain species interaction positive and negative
3. Explain how predation is beneficial in the long run

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4.9 ANSWERS TO CHECK YOUR PROGRESS

1. Mutualism is defined as an interaction between individuals of different species that results in positive (beneficial) effects on per capita reproduction and/or survival of the interacting populations.
2. When two organisms live together in which one derives nourishment at the expense of the other condition is called parasitism.

4.10 SUGGESTED READINGS

1. James P. Kimmins, 2003, Forest Ecology 3rd edition Benjamin Cummings Publisher. ISBN: 0130662585
2. Peter Stiling, 2001, Ecology- Theories and applications ISBN: 013091102X.
3. Jessica Gurevitch, 2006, The Ecology of Plants Sinauer Associates; 2nd edition ISBN:0878932941
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UNIT-5 INTRODUCTION TO BIODIVERSITY

NOTES

Structure

- 5.1 Introduction
- 5.2 Objectives
- 5.3 Introduction to Biodiversity
- 5.4 Types of Biodiversity
 - 5.4.1 Genetic Diversity
 - 5.4.2 Species diversity
 - 5.4.3 Ecosystem Diversity
 - 5.4.4 Biodiversity Concepts
- 5.5 Biodiversity Concepts
- 5.6 Centers of Diversity
- 5.7 Agro Biodiversity
- 5.8 Values and uses of Biodiversity
- 5.9 Loss of Biodiversity
- 5.10 Let us sum up
- 5.11 Unit end Exercises
- 5.12 Answer to check your progress
- 5.13 Suggested readings

5.1 INTRODUCTION

Biodiversity is typically a measure of variation at the genetic, species, and ecosystem level. Terrestrial biodiversity is usually greater near the equator, which is the result of the warm climate and high primary productivity. Biodiversity is defined as “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.”

Biodiversity hotspots: the Himalayas, the Western Ghats, the Indo-Burma region and the Sundaland (Includes Nicobar group of Islands). These hotspots have numerous endemic species. The role of biodiversity in providing ecosystem services is twofold. Firstly, biodiversity is directly used as a source for food, fibre, fuel and other extractable resources. Biodiversity has a fundamental value to humans because we are so dependent on it for our cultural, economic, and environmental well-being. Biodiversity loss is the extinction of species (plant or animal) worldwide, and also the local reduction or loss of species in a certain habitat.

Ecological effects of biodiversity are usually counteracted by its loss.

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5.2 OBJECTIVES

- To study the Biodiversity and Types of biodiversity
 - To understand the Biodiversity concepts,
 - To learn about Centres of diversity, Agro biodiversity, Values and uses of biodiversity, Loss of biodiversity.
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5.3 INTRODUCTION TO BIODIVERSITY

The great variety of life on earth has provided for man's needs over thousands of years. This diversity of living creatures forms a support system which has been used by each civilization for its growth and development. Those that used this "bounty of nature" carefully and sustainably survived. Those that overused or misused it disintegrated. Science has attempted to classify and categorize the variability in nature for over a century. This has led to an understanding of its organization into communities of plants and animals. This information has helped in utilizing the earth's biological wealth for the benefit of humanity and has been integral to the process of 'development'. This includes better health care, better crops and the use of these life forms as raw material for industrial growth which has led to a higher standard of living for the developed world. However this has also produced the modern consumerist society, which has had a negative effect on the diversity of biological resources upon which it is based. The diversity of life on earth is so great that if we use it sustainably we can go on developing new products from biodiversity for many generations. This can only happen if we manage biodiversity as a precious resource and prevent the extinction of Species.

Definition:

'Biological diversity' or biodiversity is that part of nature which includes the differences in genes among the individuals of a species, the variety and richness of all the plant and animal species at different scales in space, locally, in a region, in the country and the world, and various types of ecosystems, both terrestrial and aquatic, within a defined area.

What is biodiversity?

Biological diversity deals with the degree of nature's variety in the biosphere. This variety can be observed at three levels; the genetic variability within a species, the variety of species within a community, and the organisation of species in an area into distinctive plant and animal communities constitutes ecosystem diversity.

5.4 TYPES OF BIODIVERSITY

5.4.1 Genetic Diversity

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Each member of any animal or plant species differs widely from other individuals in its genetic makeup because of the large number of combinations possible in the genes that give every individual specific characteristics. Thus, for example, each human being is very different from all others. This genetic variability is essential for a healthy breeding population of a species. If the number of breeding individuals is reduced, the dissimilarity of genetic makeup is reduced and in-breeding occurs. Eventually this can lead to the extinction of the species. The diversity in wild species forms the '**gene pool**' from which our crops and domestic animals have been developed over thousands of years. Today the variety of nature's bounty is being further harnessed by using wild relatives of crop plants to create new varieties of more productive crops and to breed better domestic animals. Modern biotechnology manipulates genes for developing better types of medicines and a variety of industrial products.

5.4.2 Species Diversity

The number of species of plants and animals that are present in a region constitutes its species diversity. This diversity is seen both in natural ecosystems and in agricultural ecosystems. Some areas are richer in species than others. Natural undisturbed tropical forests have a much greater species richness than plantations developed by the Forest Department for timber production. A natural forest ecosystem provides a large number of non-wood products that local people depend on such as fruit, fuel wood, fodder, fiber, gum, resin and medicines. Timber plantations do not provide the large variety of goods that are essential for local consumption. In the long-term the economic sustainable returns from non-wood forest products is said to be greater than the returns from felling a forest for its timber. Thus the value of a natural forest, with all its species richness is much greater than a plantation. Modern intensive agricultural ecosystems have a relatively lower diversity of crops than traditional agropastoral farming systems where multiple crops were planted. At present conservation scientists have been able to identify and categorise about 1.8 million species on earth. However, many new species are being identified, especially in the flowering plants and insects. Areas that are rich in species diversity are called 'hotspots' of diversity. India is among the world's 15 nations that are exceptionally rich in species diversity.

5.4.3 Ecosystem Diversity

There are a large variety of different ecosystems on earth, which have their own complement of distinctive inter linked species based on the differences in the habitat. Ecosystem diversity can be described for a specific geographical region, or a political entity such as a country, a State or a taluka. Distinctive ecosystems include landscapes such as forests, grasslands, deserts, mountains, etc., as well as aquatic ecosystems such as rivers, lakes, and the sea. Each region also has man-modified areas such as farmland or grazing pastures. An ecosystem is referred to as

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'natural' when it is relatively undisturbed by human activities, or 'modified' when it is changed to other types of uses, such as farmland or urban areas. Ecosystems are most natural in wilderness areas. If natural ecosystems are overused or misused their productivity eventually decreases and they are then said to be degraded. India is exceptionally rich in its ecosystem diversity.

5.4.4 BIODIVERSITY CONCEPTS:

The world Biodiversity is now very widely used not only by the scientific community, but also the general public, environmental groups, conservationists, industrialists and economists. It has also gained a very high profile in the national and international political arena. In fact, the term has become very fashionable with no clear understanding of what it means. Such loose usage has given the word so many different meanings, connotations and intentions that the actual concept of biodiversity has been lost in obfuscation and confusion. Hence there is a real need to unequivocally define the concept of biodiversity, which is today a recognised separate science with its own principles and facts, and to define the scope of this new science as well.

Biodiversity is generally considered an umbrella term referring to organisms found within the living world i.e. the number, variety and variability of living organisms. It may thus be assumed to be a synonym for 'Life on Earth variety of life and its processes (Keystone Center 1991), 'condition of being different (Gove et al. 1996), or what Darwin (1859) exclaimed as 'Life's endless forms. Taken in this general sense, biodiversity is indeed 'the essence of life (Frankel 1970). In reality however, biodiversity is a very vast and widely used complex concept and its ramifications extend deep into all spheres of human life and activity.

Biodiversity is normally treated in terms of and in ecosystems genes, correspondence with the three fundamental hierarchical levels of biological organisation negotiation these three diversities are respectively referred to as Genetic, Species and Ecosystem diversities According to Harper and Hawksworth (1994), it was Norse et al.(1986) who first expanded the traditional use of the term biological diversity to the three levels of biological organisation (see living, into also OTA 1987). Diversity within species is aquatic syst Genetic Diversity, diversity between species is which the Species Diversity (also often referred to as Taxonomic or diversity at the ecological or habitat level is Ecosystem Diversity (also known as Ecological Biodiversit Diversity). Noss (1992, 1996), Szaro and Shapiro 1992) and (1990), Szaro and Salwasser (1991) and Wilson (1988 a,b), among many others, have included a fourth form of biodiversity called Landscape and Youne Diversity. Landscape is 'a heterogeneous land area composed of a cluster of interacting various le ecosystems that is repeated in similar form throughout' (Forman and

Godron 1986); it is also defined as 'a mosaic of heterogeneous land forms, vegetation types and land uses' (Urban et al. 1987). Landscapes therefore have a pattern and this pattern consists of repeated habitat components. For example, a landscape may be interspersed with grasslands, meadows, ponds, only be det streams, shrubby areas and forests. Thus landscape diversity is Pattern Diversity Consequen (Scheiner 1992). The inclusion of landscape Younès (1 diversity emphasised by Odum (1992) when he listed the following as one of his 20 great ideas in Ecology: An expanded approach to biodiversity should include genetic and landscape diversity, not just species diversity. Ray (1996) is also very much in favour of including landscape diversity as the fourth category, based on his studies on coastal diversities marine regions

The complexity of the biodiversity concept the importa is reflected in the existence of numerous definitions for this word, of which Jutro (1993) 'occur' at an identified at least 14. Two among these 14 levelsdefinitions are largely used, quoted and eves in officialised, since they have been apPptovedby based ystems fundamental several on countries worldwide organisation negotiations, agreements and strategies. The most-used definition is sponsored by e ctively referred dem diversities worth (1994), it United Nations (UN) and was included in th Convention on BiologicalDiversity (C0 expanded the (UNEP 1992) According to this definition cal diversity to Biodiversity refers to: The variability amo anisation (see living, inter alia, terrestrial, marine and othe hin species is aquatic systems and the ecological compleS been species is which they are part; this includes divers between species and s within species, eferred to as iversity), and ecosystems The second most-used definition abitat level is Biodiversity is sponsored by the Glob as Ecological Biodiversity Strategy (WRI, IUCN, and UNE o and Shapiro 1992) and is as follows: The totality of gme species and ecosystems in a region These two definitions, according to di C d Landscape and Younès (1996), pay very little attention t the interactions within, between and amo interacting various levels of biodiversity recognisid According to these authors, interaction is th 1986); it is principal intrinsic mechanism that shapes te characteristics and functions of biodiversit Another problem they find in the various definitions, is their ignorance of the notion scale; di Castri and Younès argue that structu and functional attributes of biodiversity c only be determined by employing appropri scales of space and time (see also Lugo 19 Consequently, according to di Castri f Landscape Younes (1996), biodiversity should not h construed as a simple umbrella covering mosaic of heterogeneous activities, but shoul represent a composite entity shaped by t continuum of all its elements and the sity, not just interactions These interactions, according very much them, are of a hierarchical nature, and)and Wilson e included a geneous land similar form geneous land ses (Urban et ve a pattern mated habitat cape may be dows, ponds rests Thus Diversity iversity was he listed the s in Ecology rsity should ersity as the interlocking the genetic, species and

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ecosystems on coastal diversities one can achieve the classic Zooming effect of hierarchical theory (Fig 1 sity concept The important outcome of such an approach that the properties of biodiversity that do n Occur at a lower scale of integration (say gene levels)will appear at high scale(say species o ecosystem level).

5.6 CENTERS OF DIVERSITY

There are at present 1.8 million species known and documented by scientists in the world. However, scientists have estimated that the number of species of plants and animals on earth could vary from 1.5 to 20 billion! Thus the majority of species are yet to be discovered.

Most of the world's bio-rich nations are in the South, which are the developing nations. In contrast, the majority of the countries capable of exploiting biodiversity are Northern nations, in the economically developed world. These nations however have low levels of biodiversity.

Thus the developed world has come to support the concept that biodiversity must be considered to be a 'global resource'. However, if biodiversity should form a 'common property resource' to be shared by all nations, there is no reason to exclude oil, or uranium, or even intellectual and technological expertise as global assets. India's sovereignty over its biological diversity cannot be compromised without a revolutionary change in world thinking about sharing of all types of natural resources. Countries with diversities higher than India are located in South America such as Brazil, and South East Asian countries such as Malaysia and Indonesia. The species found in these countries, however, are different from our own. This makes it imperative to preserve our own biodiversity as a major economic resource. While few of the other 'megadiversity nations' have developed the technology to exploit their species for biotechnology and genetic engineering, India is capable of doing so. Throughout the world, the value of biologically rich natural areas is now being increasingly appreciated as being of unimaginable value. International agreements such as the **WorldHeritage Convention** attempt to protect and support such areas. India is a signatory to the convention and has included several protected Areas as World Heritage sites. These include Manas on the border between Bhutan and India, Kaziranga in Assam, Bharatpur in U.P., Nandadevi in the Himalayas, and the Sunderbans in the Ganges delta in West Bengal. India has also signed the **Convention in theTrade of Endangered Species (CITES)** which is intended to reduce the utilization of endangered plants and animals by controlling trade in their products and in the pet trade.

5.7 AGRO BIODIVERSITY

Agricultural biodiversity is a broad term that includes all components of biological diversity of relevance to food and agriculture,

and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes

Agricultural biodiversity is the outcome of the interactions among genetic resources, the environment and the management systems and practices used by farmers. This is the result of both natural selection and human inventive developed over millennia.

The following dimensions of agricultural biodiversity can be identified:

1) Genetic resources for food and agriculture:

- Plant genetic resources, including crops, wild plants harvested and managed for food, trees on farms, pasture and rangeland species,
- Animal genetic resources, including domesticated animals, wild animals hunted for food, wild and farmed fish and other aquatic organisms,
- Microbial and fungal genetic resources.

These constitute the main units of production in agriculture, and include cultivated and domesticated species, managed wild plants and animals, as well as wild relatives of cultivated and domesticated species.

2) Components of biodiversity that support ecosystem services upon which agriculture is based. These include a diverse range of organisms that contribute, at various scales to, *inter alia*, nutrient cycling, pest and disease regulation, pollination, pollution and sediment regulation, maintenance of the hydrological cycle, erosion control, and climate regulation and carbon sequestration.

3) Abiotic factors, such as local climatic and chemical factors and the physical structure and functioning of ecosystems, which have a determining effect on agricultural biodiversity.

4) Socio-economic and cultural dimensions. Agricultural biodiversity is largely shaped and maintained by human activities and management practices, and a large number of people depend on agricultural biodiversity for sustainable livelihoods. These dimensions include traditional and local knowledge of agricultural biodiversity, cultural factors and participatory processes, as well as tourism associated with agricultural landscapes.

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5.8 VALUES AND USES OF BIODIVERSITY

The values and uses of biodiversity to human society. Smith (1776), the greatest of classical Economists, stated that 'the origin of all wealth came from the bosom of earth, implying the existence of great bondage between Economics and the Earth's resources, especially biodiversity. The value placed on biodiversity depends on whether it is a

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private or social one. Private value is given by the 'price of the resource itself, while social value refers to the value of the resource to society. The social value of biodiversity in reality refers to the manner in which bioresources are used or abused, but not actually estimated in terms of their 'worth to Society. Hence the social value of biodiversity tends to vary between countries and between cultures. Societal status, social preferences degree of technological advances and the distribution of income and assets are some of the factors largely responsible for the differential perception of value of bioresources between countries and cultures. Although for certain resources the market prices will also reflect social value, for bioresources the private value differs from the social (Perrings 1997) and the former tend to be very poor approximations of social value. The components of biodiversity are a part of the wealth of society and their allocation between competing uses largely depends on their relative private value. Private value of biodiversity components needs to be understood in order to ascertain the driving forces behind biodiversity loss, while their social value has also to be understood in order to know how much biodiversity should be conserved (Perrings 1997).

There is also a debate on whether values are to be considered equivalence measures whether values are statements of principle or a reflection of social opportunity costs (Turner and Pearce 1993; UNEP 1995), Ethical judgements influence people's preferences and therefore can be 'translated into a resources to biodiversity conservation' (Perrings 1997). Equivalence measures of value that are needed to fix the desirable level of conservation are the 'opportunities foregone in committing resources to conservation (Perrings 1997). Equivalence measures of value in reality are not blind to ethical judgements (UNEP 1995) *vice and versa*.

Individuals may place the same value on biodiversity but commit very different resources to it due to differences in their monetary endowments. For example, a developed and a developing country may place the same value on biodiversity but commit very different amounts to, say, its conservation because their monetary backgrounds differ. In other words, valuation of biodiversity reflects the relative importance of both valuation of biodiversity in a society and the latter's ability to pay for it. A rich country willing to pay more for biodiversity than a poor country does not signify that the components of biodiversity in the former are more valuable than the components of biodiversity in the poor country. In other words, the most important point here is the distribution of income and assets (Perrings 1997).

Biodiversity Values

Valuing biodiversity is mandatory even though it is really beyond valuation. At least three important systems of classification of values of biodiversity have been proposed to date whose salient features are

summarised in Box 6.1. The first system of classification of biodiversity values breaks the value down into a number of components: use or non-use, direct or indirect use, consumptive or system looks at biodiversity from the point of productive use etc. This view of a practicing economist. The most important and recent formulations incorporating these components for calculating the total value of biodiversity are provided in Box 6.1. The component formulations are defined and, in some cases i) Prim as the upor depe repr involved in these values ecos briefly explained below.

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- i) Total Environmental Value (TEV UNEP (1995) defined this as a function of primary value and total economic value A team of ecologists and economists working together arrived at a surrogate evaluation of all the environmental goods and services. It amounts to \$33 trillion worldwide per year and thus is larger than the global economy of \$29 trillion (1997 figures) (see Myers 2000). In other words, global natural resources are more valuable than global national product
- iii) The Primary Value (PV) this may be defined as the value of the system characteristics upon which all ecosystem functions depend (UNEP 1995). Therefore, it represents the prior value of the ecosystem, it is called the primary value because the structured ecosystem produces functions which secondary value. The secondary value will exist as long as the ecosystem retains its health, existence, operation and maintenance. The primary value is also known as 'glue' value since its notion is related to the fact that the system holds everything together and in principle, therefore, has economic value
- iv) Total Economic Value (TEV): Also called Total Value (TV) or simply Value (V). TEV denotes the sum total of all kinds of values attached to biodiversity minus the primary value. According to UNEP (1995) it is the function of use and non-use values, 'with due consideration of any trade-offs or mutually exclusive uses or functions of the resources/habitat in question'. Care must be taken to avoid simply adding up the resultant values to obtain TEV Total Economic Value by itself will underestimate these in some cases (TV - PV) function of use value economists surrogate value a trillion larger 9 trillion In other have homeostasis are more products the true value of ecosystems; it has to be considered along with the primary value for which details are priorly provided.
- v) Use Value (UV): This represents the value arising from an actual use made of a given component of biodiversity (MacArthur 1997). It is often a function of Direct and Indirect Use Values. Pearce (1990) and Pearce and Moran (1994) also include Option Value as a third function of use value, while

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- UNEP (1995) includes Quasi-option Value also under use value.
- vi) Direct Use Value (DUV): Also called Direct Value. MacArthur (1997) defines this as actual uses Use Value ectValu jon Value Service alue especially inconsumption. According to UNEP (1995), it represents the economic values derived from direct use or interaction with a biological resource or resource system the bioresource makes a direct contribution to human welfare in the form of either enjoyment or satisfaction. DUV is relatively easily observed and measured, often by assigning market prices. McNeely (1988) considers DUV a function of Consumptive Use Value (CUV) and Productive Use Value (PUV). Ravi and Pushpangadan (1997) consider DUV as a function of CUV, PUV and Non-consumptive Use alue (NUV). Some estimates of direct use values of selected wild resources are shown in Table 6.1.
 - vii) Consumptive Use Value (CUV): This is a type of direct use value and represents the value placed on a biodiversity component that is consumed/enjoyed directly, without passing through a market (Given 1996; Groombridge 1992; McNeely 1988). Recreation may be cited as an example. Ravi and Pushpangadan (1997) give an altogether different definition for CUV Consumption in physical form-and include all types of biomass (food, fuel, fruit, fodder, medicine, industrial raw materials such herbs for as pharmaceutical preparations, wood for different uses and microbial products) as examples. Many of these in fact do pass through a market while some do not. Consumptive use values seldom appear in the GNP of countries but are nonetheless very important. Fuel wood is a consumptive value of great importance in rural areas.
 - viii) Productive Use Value (PUV): The value given to a component of biodiversity that is commercially harvested or is a source for a commercially harvestable product such items pass through a market Examples: minor forest produce, fruitsand seeds, latex, timber, pharmaceuticals, medicines, fibres, gums and resins, wild relatives of cultivated plants. Table.6.2 provides some information on the value of productivity contributions of wild relatives of crop plants. The values of such items are usually estimated at the production end (landed value, harvested value, farm gate value etc.). PUV is included in national economic statements and budgets.
 - ix) Indirect Use Value (IUV): MacArth (1997) defined this as 'benefits arisin from an ecosystem function'. It represent the 'economic value derived from the roe of resources and systems in supporting a protecting activities whose outputs have direct re to value in production Table 6 consumption' (MacArthur

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1997; UNEP 1995). Biodiversity to human welfare are said to have this value. As examples for indirect contributions of biodiversity the following may be mentioned: biogeochemical cycles, photosynthesis, pollutant degradation, prevention of soil loss. Table.6.3 gives an idea of the indirect use value of biodiversity.

- x) Non-Consumptive Use Value (NUV): This refers to the value which the climate regulation, 3 components/systems of biodiversity possess in terms of functions or services offered. Some consider this a subcategory of IUV (Given 1996; McNeely 1988), while others (Ravi and Pushpangadan 1997) treat it as a category of DUV 1991, 992).
- xi) Non-Use Value (NV): Defined as the 'value relating to safeguarding the existence of assets, even related to their actual use in a foreseeable though not period' (MacArthur 1997). NV is also referred to as Passive Use Value, referring to the value of a biodiversity resource in production or consumption thing other than the user such a value exists 'where individuals who do not intend to make use of such resources would nevertheless feel a "loss" if they were to disappear' (Brown 1990; Randall 1991). In view of this, people may like to conserve such biodiversity resources in their own right.
- xii) Option willingness to pay to safeguard an asset for the option of using it in future' (MacArthur 1997). UNEP (1995) defined OV as follows: The potential value of the resource for future (direct and indirect) use'. The wild relatives of cultivated Defined Value (OV): as plants that are yet to be exploited may be cited examples of biodiversity as components possessing OV.
- xiii) Quasi-Option Value (QOV): According to UNEP (1995), QOV represents 'the value of the future information made available through the preservation of a resource' (also see Arrow and Fisher 1974). It should be mentioned that the distinction between option and quasi- option values is not always maintained.
- xiv) Existence Value (EV): Defined as the value 'deriving from the existence of a particular asset (MacArthur 1997). UNEP (1995) defines EV as: The value of knowing that a particular species, habitat or ecosystem does and will continue to exist. It is independent of any use that the value may make of the resource'. EV notes the benefits derived by any one individual from the mere knowledge that the bioresource exists (see Pearce and Moran 1994). People who have donated money to a conservation organisation without expecting anything in return other than the satisfaction of knowing they have contributed something to the cause of biodiversity, may be said to have

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realised the existence value of biodiversity. Existence values of biodiversity generally generate sympathy and concern among people.

- xv) Bequest Value (BV): This is the 'value of knowing that others may benefit from the existence of an asset in future' (MacArthur 1997). According to UNEP (1995) it is a 'value defined by willingness to pay, to ensure that people's offspring or future generation's environmental asset'. This value may thus be considered as the value of keeping a resource intact for one's heirs (Krutilla 1967). Some people, for example Aldred (1994), view BV as merely one of a number of types of Existence Value, and not warranting a separate category

Ethical and Aesthetic

Values these two categories of intrinsic values (as per the system found in Meffe and Carroll 1994; Norton 1987, 1994) warrant special discussion. For some cultures, especially those in existence for several centuries, ethical benefits provide the strongest grounds for their deep concern for biodiversity. In India and certain East Asian countries, biodiversity is considered to have great value on cultural and religious grounds (see Chapter 8, for further details). Realising the importance of ethical value, the IUCN's Working Group on Ethics and Conservation produced a document on the ethical foundation for conservation of biodiversity (IUCN/UNEP/ WWF 1990). The implications of this document were detailed by Engel and Engel (1990). Moral and ethical values differ from place to place culture to culture, time to time and person to person. They also differ between different components of biodiversity. For example, the ethical value attached to sacred basil is not accorded to a cactus in India. In other words most people value certain species more than others almost subconsciously.

The aesthetic value of biodiversity is very well known. Most people react more aesthetically (often instinctively) towards plants that are appealing, visually or otherwise. Most cultures, irrespective of geographic location, have attested to the effect of plant and animal beauty on the human mind and emotions. Poets, writers and artists from various cultures have given expression to the aesthetic appeal of plants and animals. However, the relative aesthetic judgements differ from place to place time to time and culture to culture. Roses, for example, kindle the aesthetic sense much more than cacti, succulents and carnivorous plants although the latter have their own admirers. Such relative aesthetic judgements could presumably compel greater concern for certain biodiversity elements than for others, those deemed aesthetically not worthy'. Interestingly, the plant and animal species that

particularly deserve protection, quite often have the least aesthetic appeal.

5.9 LOSS OF BIODIVERSITY

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While it is doubtful if any new species are being added (through speciation) into the earth's treasury of species, there is no doubt about their continuing losses. The biological wealth of our planet has been declining rapidly and the accusing finger is clearly pointing to human activities. The colonisation of tropical Pacific Islands by humans is said to have led to the extinction of more than 2,000 species of native birds. The IUCN Red List (2004) documents the extinction of 784 species (including 338 vertebrates, 359 invertebrates and 87 plants) in the last 500 years. Some examples of recent extinctions include the dodo (Mauritius), quagga (Africa), thylacine (Australia), Steller's Sea Cow (Russia) and three subspecies (Bali, Javan, Caspian) of tiger. The last twenty years alone have witnessed the disappearance of 27 species. Careful analysis of records shows that extinctions across taxa are not random; some groups like amphibians appear to be more vulnerable to extinction. Adding to the grim scenario of extinctions is the fact that more than 15,500 species world-wide are facing the threat of extinction. Presently, 12 per cent of all bird species, 23 per cent of all mammal species, 32 per cent of all amphibian species and 31 per cent of all gymnosperm species in the world face the threat of extinction. From a study of the history of life on earth through fossil records, we learn that large-scale loss of species like the one we are currently witnessing have also happened earlier, even before humans appeared on the scene. During the long period (> 3 billion years) since the origin and diversification of life on earth there were five episodes of mass extinction of species. How is the 'Sixth Extinction' presently in progress different from the previous episodes? The difference is in the rates; the current species extinction rates are estimated to be 100 to 1,000 times faster than in the pre-human times and our activities are responsible for the faster rates. Ecologists warn that if the present trends continue, nearly half of all the species on earth might be wiped out within the next 100 years. In general, loss of biodiversity in a region may lead to (a) decline in plant production, (b) lowered resistance to environmental perturbations such as drought and (c) increased variability in certain ecosystem processes such as plant productivity, water use, and pest and disease cycles.

Causes of biodiversity losses: The accelerated rates of species extinctions that the world is facing now are largely due to human activities. There are four major causes (The Evil Quartet' is the sobriquet used to describe them).

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(i) Habitat loss and fragmentation: This is the most important cause driving animals and plants to extinction. The most dramatic examples of habitat loss come from tropical rain forests. Once covering more than 14 per cent of the earth's land surface, these rain forests now cover no more than 6 per cent. They are being destroyed fast. By the time you finish reading this chapter, 1000 more hectares of rain forest would have been lost. The Amazon rain forest (it is so huge that it is called the 'lungs of the planet') harbouring probably millions of species is being cut and cleared for cultivating *soya beans* or for conversion to grasslands for raising beef cattle. Besides total loss, the degradation of many habitats by pollution also threatens the survival of many species. When large habitats are broken up into small fragments due to various human activities, mammals and birds requiring large territories and certain animals with migratory habits are badly affected, leading to population declines.

(ii) Over-exploitation: Humans have always depended on nature for food and shelter, but when 'need' turns to 'greed', it leads to over-exploitation of natural resources. Many species extinctions in the last 500 years (Steller's sea cow, passenger pigeon) were due to overexploitation by humans. Presently many marine fish populations around the world are over harvested, endangering the continued existence of some commercially important species.

(iii) Alien species invasions: When alien species are introduced unintentionally or deliberately for whatever purpose, some of them turn invasive, and cause decline or extinction of indigenous species. The Nile perch introduced into Lake Victoria in east Africa led eventually to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish in the lake. You must be familiar with the environmental damage caused and threat posed to our native species by invasive weed species like carrot grass (*Parthenium*), *Lantana* and water hyacinth (*Eicchornia*). The recent illegal introduction of the African catfish *Clarias gariepinus* for aquaculture purposes is posing a threat to the indigenous catfishes in our rivers

(iv) Co-extinctions: When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct. When a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate. Another example is the case of a coevolved plant-pollinator mutualism where extinction of one invariably leads to the extinction of the other.

Check your Progress

1. What is Biodiversity?
2. Give hierarchical levels of biodiversity
3. What is genetic biodiversity

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5.10 LET US SUM UP

In this unit discuss about biodiversity and its conservations. Biodiversity is the variety and variability of life on Earth. Biodiversity is typically a measure of variation at the genetic, species, and ecosystem level. It has been estimated that more than 50 million species of plants, animals and micro-organisms are existing in the world. The role of biodiversity in providing ecosystem services is twofold. Firstly, biodiversity is directly used as a source for food, fibre, fuel and other extractable resources. Biodiversity loss is the extinction of species (plant or animal) worldwide, and also the local reduction or loss of species in a certain habitat.

5.11 UNIT END EXERCISES

1. What you understand by species biodiversity
2. How biodiversity use for agriculture?
3. What are the patterns of biodiversity?

5.12 ANSWER TO CHECK YOUR PROGRESS

1. Biodiversity is defined as “the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.”
2. There are three interrelated **hierarchical levels of biodiversity** namely, genetic diversity, species diversity and community or ecosystem diversity.
3. Each member of any animal or plant species differs widely from other individuals in its genetic makeup because of the large number of combinations possible in the genes that give every individual specific characteristics.

5.13 SUGGESTED READINGS

1. D.L. Hawskworth, 2009, Methods and Practice in Biodiversity Conservation, Springer, ISBN:9789048138487
2. K. V. Krishnamurthy, 2003, Textbook of Biodiversity, Science Publishers, USA, ISBN: 1-57808-325-7.

UNIT-6 PHYTOGEOGRAPHY ZONES

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Structure

- 6.1 Introduction
- 6.2 Objectives
- 6.3 Phytogeography zones
- 6.4 Vegetation types of India and TamilNadu
 - 6.4.1 Vegetation types of India
 - 6.4.2 Types of Natural Vegetation in India
- 6.5 Endemism
- 6.6 Red listed plants,
- 6.7 Red Data Book,
- 6.8 Threatened plants and animals of India
- 6.9 Let us sum up
- 6.10 Unit end Exercises
- 6.11 Answer to check your progress
- 6.12 Suggested readings

6.1 INTRODUCTION

A phytogeographical region is defined as an area of uniform climatic conditions and having a distinctly recognisable type of vegetation. According to D. Chattarjee (1962), India can be divided into nine phytogeographical regions. India has a wide range of natural vegetation. Vegetation of India can be divided into five types – Tropical evergreen forest, Tropical deciduous forest, Thorny bushes, Mountain vegetation and Mangrove forests.

Endemism is the ecological state of a species being unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere. The Red Data Book is the state document established for documenting rare and endangered species of animals, plants and fungi as well as some local sub-species that exist within the territory of the state or country. Loss of native plant habitat is most often the principal reason why plants become endangered. ... The most common cause of plant habitat loss and subsequent plant rarity and endangerment is conversion of native plant habitat to cities, farms, roads, and regulated-flow river systems and reservoirs. The flora of India is one of the richest in the world due to the wide range of climate, topology and habitat in the country. There are estimated to be over 18,000 species of flowering plants in India, which constitute some 6-7 percent of the total plant species in the world.

6.2 OBJECTIVES

- To know about Phytogeographic zones of India and Tamilnadu
- To study the history of forest and Vegetation types of India and Tamilnadu
- To study and impart knowledge about the occurrence and distribution of Endemic species, Red listed plants, Red Data Book, Threatened plants and animals of India.

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6.3 PHYTOGEOGRAPHIC ZONES

Our country can be conveniently divided into ten major regions, based on the geography, climate and pattern of vegetation seen and the communities of mammals, birds, reptiles, amphibia, insects and other invertebrates that live in them. Each of these regions contains a variety of ecosystems such as forests, grasslands, lakes, rivers, wetlands, mountains and hills, which have specific plant and animal species.

India's Biogeographic Zones

1. The cold mountainous snow covered Trans Himalayan region of Ladakh.
2. The Himalayan ranges and valleys of Kashmir, Himachal Pradesh, Uttarakhand, Assam and other North Eastern States.
3. The Terai, the lowland where the Himalayan Rivers flow into the plains.
4. The Gangetic and Bhrmaputra plains.
5. The Thar Desert of Rajasthan.
6. The semi arid grassland region of the Deccan plateau Gujarat, Maharashtra, Andra Pradesh, Karnataka and Tamil Nadu.
7. The Northeast States of India,
8. The Western Ghats in Maharashtra, Karnataka and Kerala.
9. The Andaman and Nicobar Islands.
10. The long western and eastern coastal belt with sandy beaches, forests and mangrove

6.4 VEGETATION TYPES OF INDIA AND TAMILNADU

6.4.1 Vegetation types of India

Geological events in the landmass of India have provided conditions for high levels of biological diversity. A split in the single giant continent around 70 million years ago, led to the formation of northern and southern continents, with India a part of Gondwanaland - the southern landmass, together with Africa, Australia and the Antarctic. Later tectonic movements shifted India northward across the equator to join the Northern Eurasian continent. As the intervening shallow Tethis

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Sea closed down, plants and animals that had evolved both in Europe and in the Far East migrated into India before the Himalayas had formed. A final influx came from Africa with Ethiopian species, which, were adapted to the Savannas and semi-arid regions. Thus India's special geographical position between three distinctive centres of biological evolution and radiation of species is responsible for our rich and varied biodiversity.

Among the biologically rich nations, India stands among the top 10 or 15 countries for its great variety of plants and animals, many of which are not found elsewhere. India has 350 different mammals (rated eight highest in the world), 1,200 species of birds (eighth in the world), 453 species of reptiles (fifth in the world) and 45,000 plant species, of which most are angiosperms, (fifteenth in the world). These include especially high species diversity of ferns (1022 species) and orchids (1082 species). India has 50,000 known species of insects, including 13,000 butterflies and moths. It is estimated that the number of unknown species could be several times higher. It is estimated that 18% of Indian plants are **endemic** to the country and found nowhere else in the world. Among the plant species the flowering plants have a much higher degree of endemism, a third of these are not found elsewhere in the world. Among amphibians found in India, 62% are unique to this country. Among lizards, of the 153 species recorded, 50% are endemic. High endemism has also been recorded for various groups of insects, marine worms, centipedes, mayflies and fresh water sponges.

6.4.2 Types of Natural Vegetation in India

1. Tropical Evergreen Rain Forests.
2. Deciduous or Monsoon Type of Forests.
3. Dry Deciduous Forests.
4. Mountain Forests.
5. Tidal or Mangrove Forests.
6. Semi-Desert and Desert Vegetations.
- 7.

6.5 ENDEMISM

To appreciate the endemic and endangered species of India it is important to understand the wide variety of plant and animal species that are found in the country. Of the well-known species, there are several which are endangered by human activity. The endangered species in the country are categorised as Vulnerable, Rare, Indeterminate and Threatened. Other species are found only in India and are thus endemic or restricted to our country. Some of these may have very localized distribution and are considered highly endemic. Several plant and animal species in the country are now found in only one or a few Protected Areas. Among the important endangered animals are charismatic species such as the tiger, the elephant, the rhino, etc. The less well-known major

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mammals restricted to a single area include the Indian wild ass, the Hangul or Kashmir stag, the Golden langur, the pygmy hog and a host of others. There are also endangered bird species such as the Siberian crane, the Great Indian Bustard, the Florican and several birds of prey. During the recent past, vultures which were common a decade ago, have suddenly disappeared and are now highly threatened. Equally threatened are several species of reptiles and amphibia. Many invertebrates are also threatened, including a large number of species that inhabit our coralreefs. Many plant species are now increasingly threatened due to changes in their habitats induced by human activity. Apart from major trees, shrubs and climbers that are extremely habitat specific and thus endangered, there are thousands of small herbs which are greatly threatened by habitat loss. Several orchids are yet another group of plants that are under threat. Many plants are threatened due to overharvesting as ingredients in medicinal products.

To protect endangered species India has created the Wildlife Protection Act. This includes lists of plants and animals categorised according to the threat on their survival. We know so little about the species diversity of our country. There are several groups of which we know very little. Most of us are only aware of the plight of a few glamorous large mammals, but we need to appreciate the threat to the less known species of plants and animals. We need to find ways to support the conservation of our incredible wildlife for future generations.

Red listed plants, Red Data Book,
Threatened plants and animals of India.

6.6 RED LIST OF PLANTS

Name of the plant	Family	Distribution	Status
<i>Barleria gibsonioides</i> Blatt. et McC.	ACANTHACEAE	Maharashtra	R
<i>Dicliptera abuensis</i> Blatt.	ACANTHACEAE	Rajasthan	E
<i>Dicliptera ghatica</i> Sant.	ACANTHACEAE	Maharashtra	I
<i>Hypoestes andamanensis</i> Thoth.	ACANTHACEAE	Andaman & Nicobar	V
<i>Hypoestes lanata</i> Dalz.	ACANTHACEAE	Maharashtra	R
<i>Lepidagathis barberi</i> Gamble	ACANTHACEAE	Tamil Nadu	R
<i>Lepidagathis difusa</i> Clarke	ACANTHACEAE	Karnataka, Tamil Nadu	I
<i>Mackenzia caudata</i> (T. And.) Ramam.	ACANTHACEAE	Karnataka, Tamil Nadu	R
<i>Neuracanthus neesianus</i> (Wight ex T. Anders.) Clarke	ACANTHACEAE	Tamil Nadu	E or Possibly Ex
<i>Nilgirianthus circarensis</i> (Gamble) Bremek.	ACANTHACEAE	Andhra Pradesh, Orissa	R
<i>Phlebophyllum jeyaporensis</i> (Bedd.) Bremekamp	ACANTHACEAE	Madhya Pradesh, Orissa, Andhra	E

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		Pradesh	
<i>Santapaua madurensis</i> Balakr. & Subram.	ACANTHACEAE	Tamil Nadu	E
<i>Strobilanthes dupenii</i> Bedd. ex Clarke	ACANTHACEAE	Peninsular India (Anamalais)	I
<i>Strobilanthes hallbergii</i> Blatter	ACANTHACEAE	Rajasthan	E
<i>Acer caesium</i> Wall. ex Brandis	ACERACEAE	Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh	V
<i>Acer hookeri</i> Miquel var. <i>majus</i> Pax	ACERACEAE	West Bengal	E
<i>Acer oblongum</i> Wall. ex DC. var. <i>membranaceum</i> Banerji	ACERACEAE	Uttar Pradesh	E
<i>Acer oblongum</i> Wall. ex DC. var. <i>microcarpum</i> Hiern	ACERACEAE	Arunachal Pradesh	E
<i>Acer osmastonii</i> Gamble	ACERACEAE	West Bengal	E
<i>Acer sikkimense</i> Miq. var. <i>serrulatum</i> Pax	ACERACEAE	Arunachal Pradesh	E
<i>Adiantum soboliferum</i> Wall. ex Hook.	ADIANTACEAE	Assam, Nagaland	Possibly Extinct
<i>Weisneria triandra</i> (Dalz.) Micheli	ALISMATACEAE	Maharashtra, Goa	R
<i>Allium stracheyi</i> Baker	ALLIACEAE	Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh	V
<i>Achyranthes coynei</i> Sant.	AMARANTHACEAE	Maharashtra	R
<i>Aerva wightii</i> Hook. f.	AMARANTHACEAE	Tamil Nadu	I
<i>Crinum eleonorae</i> Blatt. & McC.	AMARYLLIDACEAE	Maharashtra	R
<i>Buchanania beriberi</i> Gamble	ANACARDIACEAE	Kerala	E
<i>Buchanania platyneura</i> Kurz	ANACARDIACEAE	Andaman & Nicobar Islands	I
<i>Mangifera andamanica</i> King	ANACARDIACEAE	South Andaman	V
<i>Nothopegia aureo-fulva</i> Bedd. ex Hook. f.	ANACARDIACEAE	Tamil Nadu	E
<i>Artabotrys nicobaricus</i> D. Das	ANNONACEAE	Nicobar Islands	R
<i>Desmos viridiflorus</i> (Bedd.) Safford	ANNONACEAE	Tamil Nadu, Kerala	E
<i>Goniothalamus rhynchantherus</i> Dun n	ANNONACEAE	Tamil Nadu, Kerala	R
<i>Miliusa nilagirica</i> Bedd.	ANNONACEAE	Tamil Nadu	V
<i>Mitrephora andamanica</i> Thoth. & D. Das	ANNONACEAE	Andaman Islands	R
<i>Orophea uniflora</i> Hook. f. & Thoms.	ANNONACEAE	Tamil Nadu, Karnataka	R
<i>Phaeanthus malabaricus</i> Bedd.	ANNONACEAE	Kerala	V
<i>Polyalthia rufescens</i> Hook. f. & Thoms.	ANNONACEAE	Tamil Nadu, Kerala	R
<i>Popowia beddomeana</i> Hook. f. & Thoms.	ANNONACEAE	Tamil Nadu, Kerala	R

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<i>Pseuduvaria prainii</i> (King) Merr.	ANNONACEAE	Andaman & Great Nicobar Islands	R
<i>Sageraea grandiflora</i> Dunn	ANNONACEAE	Kerala	E, Possible Extinct
<i>Trivalvaria kanjilalii</i> D. Das	ANNONACEAE	Meghalaya	E
<i>Uvaria eucineta</i> Bedd. ex Dunn	ANNONACEAE	Orissa	E
<i>Uvaria nicobarica</i> Raiz. & Sahni	ANNONACEAE	Great Nicobar island	R
<i>Acronema pseudotenera</i> Mukh.	APIACEAE	Sikkim	I
<i>Angelica nubigena</i> (Clarke) Mukh. [Heracleum nubigenum Clarke]	APIACEAE	Sikkim	I
<i>Bunium nothum</i> (Clarke) Mukh. [Carum nothum Clarke]	APIACEAE	S. India (Nilgiri)	Possibly Extinct
<i>Carum villosum</i> Haines	APIACEAE	Bihar	Possible Extinct
<i>Chaerophyllum orientalis</i> (Clarke) Mukh. [C. reflexum var. orientalis Clarke]	APIACEAE	Nagaland, Arunachal Pradesh	I
<i>Heracleum jacquemontii</i> Clarke	APIACEAE	North West Himalaya	I
<i>Hydrocotyle conferta</i> Wt.	APIACEAE	Nilgiri & Pulney hills	R
<i>Ligusticum albo-alatum</i> Haines	APIACEAE	Bihar	Possibly Extinct
<i>Peucedanum anamallayense</i> Clarke	APIACEAE	Tamil Nadu	R
<i>Pimpinella evoluta</i> (Clarke) Mukh.	APIACEAE	Nagaland (Naga Hills)	Possibly Extinct
<i>Pimpinella flaccida</i> Clarke	APIACEAE	Nagaland	I
<i>Pimpinella katrajensis</i> Rao et Hemadri	APIACEAE	Maharashtra	R
<i>Pimpinella pulneyensis</i> Gamble	APIACEAE	S. India (Pulney hills)	Possibly Extinct
<i>Pimpinella tirupatiensis</i> Balakr. et Subram.	APIACEAE	Andhra Pradesh	E
<i>Pimpinella tongloensis</i> Mukh.	APIACEAE	West Bengal	E
<i>Pimpinella wallichii</i> Clarke	APIACEAE	Sikkim	E
<i>Polyzygus tuberosus</i> Dalz.	APIACEAE	Maharashtra, Karnataka	R
<i>Ptenopetalum radiatum</i> (W.W. Sm.) Mukh. [Pimpinella radiata W.W. Sm.]	APIACEAE	Sikkim	I
<i>Ptenopetalum senii</i> Deb et Dutta	APIACEAE	Arunachal Pradesh	R
<i>Vanasushava pedata</i> (Wight) Mukh. et Const.	APIACEAE	S. India (Shevagherry, Palni and Anamalis hills)	R
<i>Aponogeton appendiculatus</i> van	APONOGETONACEAE	Kerala,	I

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<i>Bruggen</i>		Tamil Nadu.	
<i>Aponogeton satarensis</i> R. Sundararaghavan, A.R. Kulk. & S.R. Yadav	APONOGETONACEAE	Maharashtra	V
<i>Ilex gardneriana</i> Wight	AQUIFOLIACEAE	Peninsular India (Nilgiri)	Possibly Extinct
<i>Amorphophallus longistylus</i> Kurz ex Hook. f.	ARACEAE	South Andaman Island	R
<i>Amorphophallus oncophyllus</i> Prain ex Hook. f.	ARACEAE	South Andaman Island	R
<i>Cryptocoryne cognate</i> Schott	ARACEAE	Maharashtra	I
<i>Cryptocoryne cognatoides</i> Blatt. & McC.	ARACEAE	Karnataka, Maharashtra	V
<i>Cryptocoryne tortuosa</i> Blatt. & McC.	ARACEAE	Maharashtra	E
<i>Typhonium incurvatum</i> Blatt. & McC.	ARACEAE	Maharashtra	R
<i>Panax pseudo-ginseng</i> Wall.	ARALIACEAE	E. Himalaya	V
<i>Bentinckia condapanna</i> Berry ex Roxb.	ARECACEAE	Kerala	R
<i>Bentinckia nicobarica</i> (Kurz) Becc.	ARECACEAE	Nicobar Islands	E
<i>Calamus dilaceratus</i> Becc.	ARECACEAE	Andaman Islands	R
<i>Calamus inermis</i> T. Anders.	ARECACEAE	Sikkim	E
<i>Calamus nagbettai</i> Fernandez et Dey	ARECACEAE	Karnataka	V
<i>Corypha macropoda</i> Lindel ex Kurz	ARECACEAE	South Andaman Island	R
<i>Korthalsia rogersii</i> Becc.	ARECACEAE	South Andaman Island	R
<i>Livistona jenkinsiana</i> Griff.	ARECACEAE	Sikkim, Assam, Meghalaya, Arunachal Pradesh	E
<i>Phoenix rupicola</i> T. Anders.	ARECACEAE	Sikkim, West Bengal, Arunachal Pradesh, Meghalaya	R
<i>Pinanga andamanensis</i> Becc.	ARECACEAE	Andaman Islands	R
<i>Pinanga manii</i> Becc.	ARECACEAE	Nicobar & South Andaman Islands	V
<i>Trachycarpus takil</i> Becc.	ARECACEAE	Uttar Pradesh	R
<i>Wallichia triandra</i> (Joseph) S.K. Basu	ARECACEAE	Arunachal Pradesh	R
<i>Thottea barberi</i> (Gamble) Ding Hou	ARISTOLOCHIACEAE	Tirunelveli	V

NOTES

<i>Ceropegia angustifolia</i> Wight	ASCLEPIADACEAE	Meghalaya	V
<i>Ceropegia arnottiana</i> Wight	ASCLEPIADACEAE	Meghalaya	E or Possibly Extinct
<i>Ceropegia attenuata</i> Hook.	ASCLEPIADACEAE	Maharashtra , Karnataka	R
<i>Ceropegia barnesii</i> Bruce et Chatterjee	ASCLEPIADACEAE	S. India	E
<i>Ceropegia beddomei</i> Hook. f.	ASCLEPIADACEAE	Kerala	E
<i>Ceropegia decaisneana</i> Wight	ASCLEPIADACEAE	Kerala, Tamil Nadu	R
<i>Ceropegia evansii</i> McCann Wight	ASCLEPIADACEAE	Maharashtra	V
<i>Ceropegia fantastica</i> Sedgw.	ASCLEPIADACEAE	Karnataka, Goa	E or Possibly Extinct
<i>Ceropegia fimbriifera</i> Bedd.	ASCLEPIADACEAE	Karnataka, Tamil Nadu	V
<i>Ceropegia hookeri</i> Clarke ex Hook. f.	ASCLEPIADACEAE	Sikkim	E
<i>Ceropegia huberi</i> Ansari	ASCLEPIADACEAE	Maharashtra	V
<i>Ceropegia jainii</i> Ansari et Kulkarni	ASCLEPIADACEAE	Maharashtra	R
<i>Ceropegia lawii</i> Hook. f.	ASCLEPIADACEAE	Maharashtra	E
<i>Ceropegia lucida</i> Wall.	ASCLEPIADACEAE	Meghalaya, Assam, Sikkim	E or Possibly Extinct
<i>Ceropegia maculata</i> Bedd. [<i>C. parviflora</i> Trimen]	ASCLEPIADACEAE	Tamil Nadu, Kerala	E or Possibly Extinct
<i>Ceropegia maccannii</i> Ansari	ASCLEPIADACEAE	Maharashtra	R
<i>Ceropegia mahabalei</i> Hemadri et Ansari	ASCLEPIADACEAE	Maharashtra	E
<i>Ceropegia metziana</i> Miq.	ASCLEPIADACEAE	Karnataka, Tamil Nadu, Kerala	R
<i>Ceropegia noorjahaniae</i> Ansari	ASCLEPIADACEAE	Maharashtra	R
<i>Ceropegia oculata</i> Hook. f.	ASCLEPIADACEAE	Maharashtra	R
<i>Ceropegia odorata</i> Nimmo ex Hook. f.	ASCLEPIADACEAE	Maharashtra , Rajasthan	E
<i>Ceropegia omissa</i> Huber [<i>C. intermedia</i> Wight var. <i>wightii</i> Hook. f.]	ASCLEPIADACEAE	Tamil Nadu	E
<i>Ceropegia panchganiensis</i> Blatter et McC.	ASCLEPIADACEAE	Maharashtra	E
<i>Ceropegia pusilla</i> Wight et Arn.	ASCLEPIADACEAE	Karnataka, Tamil Nadu, Kerala	R
<i>Ceropegia rollae</i> Hemadri	ASCLEPIADACEAE	Maharashtra	R
<i>Ceropegia sahyadrica</i> Ansari et Kulkarni	ASCLEPIADACEAE	Maharashtra	R
<i>Ceropegia santapau</i> Wadhwa et Ansari	ASCLEPIADACEAE	Maharashtra	R
<i>Ceropegia spiralis</i> Wight	ASCLEPIADACEAE	Andhra Pradesh, Karnataka, Tamil Nadu,	V

NOTES

		Kerala	
<i>Ceropegia thwaitesii</i> Hook.	ASCLEPIADACEAE	Tamil Nadu, Kerala	V
<i>Ceropegia vincaefolia</i> Hook. emend. Ansari	ASCLEPIADACEAE	Maharashtra	R
<i>Frerea indica</i> Dalz.	ASCLEPIADACEAE	Maharashtra	E
<i>Gymnema khandalense</i> Santapau	ASCLEPIADACEAE	Maharashtra	R
<i>Marsdenia raziana</i> Yog. et Subr.	ASCLEPIADACEAE	Karnataka	R
<i>Oianthus deccanensis</i> Talb.	ASCLEPIADACEAE	Maharashtra	E or Possibly Extinct
<i>Seshagiria sahyadrica</i> Ansari et Hemadri	ASCLEPIADACEAE	Maharashtra	R
<i>Toxocarpus beddomei</i> Gamble	ASCLEPIADACEAE	Tamil Nadu, Kerala	R
<i>Toxocarpus longistigma</i> (Roxb.) Wight & Arn. ex Steud.	ASCLEPIADACEAE	Andhra Pradesh	E
<i>Toxocarpus palghatensis</i> Gamble	ASCLEPIADACEAE	Kerala	V
<i>Asparagus jacquemonti</i> Baker	ASPARAGACEAE	Maharashtra, Kerala	I
<i>Asparagus rotleri</i> Baker	ASPARAGACEAE	Deccan Peninsula	I or Insufficiently Known
<i>Lastreopsis wattii</i> (bedd.) Tagawa	ASPIDIACEAE	Manipur	Presumed Extinct
<i>Anaphalis barnesii</i> C.E.C. Fischer	ASTERACEAE	Kerala	E
<i>Catamixis baccharoides</i> Thoms.	ASTERACEAE	Uttar Pradesh (Garhwal)	V
<i>Chondrilla setulosa</i> Clarke ex Hook. f.	ASTERACEAE	Jammu & Kashmir	R
<i>Cyathocline lutea</i> Law ex Wight	ASTERACEAE	Maharashtra, Karnataka	R
<i>Helichrysum cutchicum</i> (C.B. Clarke) Rolla Rao et Deshpande	ASTERACEAE	Gujarat	R
<i>Helichrysum perlanigerum</i> Gamble	ASTERACEAE	Tamil Nadu	R
<i>Inula kalapani</i> Clarke	ASTERACEAE	Meghalaya	R
<i>Inula racemosa</i> Hook. f.	ASTERACEAE	Jammu & Kashmir	V
<i>Lactuca benthamii</i> Clarke	ASTERACEAE	Jammu & Kashmir	E
<i>Lactuca cooperi</i> Anthony	ASTERACEAE	Sikkim	E
<i>Lactuca filicina</i> Duthie ex Stebbins	ASTERACEAE	Uttar Pradesh (Kumaon)	E
<i>Lactuca undulata</i> Ledeb.	ASTERACEAE	Jammu & Kashmir	E
<i>Nanothamnus sericeus</i> Thoms.	ASTERACEAE	Maharashtra, Karnataka	R
<i>Senecio kundaicus</i> Fischer	ASTERACEAE	Tamil Nadu	E
<i>Senecio mayurii</i> Fischer	ASTERACEAE	Karnataka	R
<i>Senecio mishmi</i> Clarke	ASTERACEAE	Meghalaya	V or I
<i>Senecio rhabdos</i> Clarke	ASTERACEAE	Nagaland, Manipur	R
<i>Saussurea bracteata</i> Decne.	ASTERACEAE	Jammu & Kashmir, Himachal Pradesh, Uttar	R

NOTES

		Pradesh	
<i>Saussurea costus</i> (Falc.) Lipschitz	ASTERACEAE	Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh	E
<i>Saussurea clarkei</i> Hook. f.	ASTERACEAE	Jammu & Kashmir	R
<i>Synotis simonsii</i> (Clarke) Jeffrey et Chen	ASTERACEAE	Assam	I
<i>Vernonia andamanica</i> Balakr. & N.G. Nair	ASTERACEAE	North Andaman	R
<i>Vernonia multibracteata</i> Gamble	ASTERACEAE	Kerala	E
<i>Vernonia pulneyensis</i> Gamble	ASTERACEAE	Pulney Hills	E
<i>Vernonia recurva</i> Bedd. ex S. Moore	ASTERACEAE	Tamil Nadu	E or Possibly Extinct
<i>Youngia silgiriensis</i> Bebbcock	ASTERACEAE	Nilgiri Hills and Sispara of Western Ghats	E
<i>Athyrium atratum</i> Bedd.	ATHYRIACEAE	Manipur	E
<i>Athyrium duthei</i> (Bedd.) Bedd.	ATHYRIACEAE	North West and Eastern Himalaya	V
<i>Diplazium travancoricum</i> Bedd.	ATHYRIACEAE	S. India	R
<i>Rhopalocnemis phalloides</i> Jungh.	BALANOPHORACEAE	Meghalaya, Arunachal Pradesh, Sikkim	R
<i>Impatiens anaimudica</i> Fischer	BALSAMINACEAE	Kerala	E or Possibly Extinct
<i>Impatiens johnii</i> E. Barnes	BALSAMINACEAE	Kerala	E or Possibly Extinct
<i>Impatiens macrocarpa</i> Hook. f.	BALSAMINACEAE	Kerala	E or Possibly Extinct
<i>Impatiens munnarensis</i> E. Barnes	BALSAMINACEAE	Kerala	E
<i>Impatiens neo-barnesii</i> Fischer	BALSAMINACEAE	Tamil Nadu	E
<i>Impatiens nilagirica</i> Fischer	BALSAMINACEAE	Tamil Nadu	E
<i>Impatiens pandata</i> E. Barnes	BALSAMINACEAE	Kerala	R
<i>Impatiens talbortii</i> Hook. f.	BALSAMINACEAE	Karnataka	R
<i>Begonia aborensis</i> Dunn	BEGONIACEAE	Arunachal Pradesh	R
<i>Begonia aliciae</i> C.E.C. Fischer	BEGONIACEAE	Kadalar valley and Nilgiri hills, Souther W. Ghats	E
<i>Begonia anamalayana</i> Bedd.	BEGONIACEAE	Southern W. Ghats	E
<i>Begonia brevicaulis</i> DC.	BEGONIACEAE	Meghalaya	E or possibly

NOTES

			Extinct
<i>Begonia burkillii</i> Dunn	BEGONIACEAE	Arunachal Pradesh	R
<i>Begonia canarana</i> Miq.	BEGONIACEAE	South West India, Western Ghats	E or Possibly Extinct
<i>Begonia cordifolia</i> (Wight) Thw.	BEGONIACEAE	South Deccan Peninsula, Western Ghats	R
<i>Begonia lushaiensis</i> C.E.C. Fischer	BEGONIACEAE	Mizoram	R
<i>Begonia phrixophylla</i> Blatt. et McC.	BEGONIACEAE	Maharashtra	R
<i>Begonia rubella</i> Buch.-Ham. ex D. Don	BEGONIACEAE	Sikkim	R
<i>Begonia rubrovenia</i> var. <i>meisneri</i> Clarke	BEGONIACEAE	Meghalaya	R
<i>Begonia satrapis</i> Clarke	BEGONIACEAE	West Bengal, Sikkim	R
<i>Begonia scintillans</i> Dunn	BEGONIACEAE	Arunachal Pradesh	I
<i>Begonia scutata</i> Wall. ex DC.	BEGONIACEAE	West Bengal, Sikkim	R
<i>Begonia subpeltata</i> Wight	BEGONIACEAE	South Deccan Peninsula, Western Ghats (Malabar)	R
<i>Begonia tessaricarpa</i> Clarke	BEGONIACEAE	Assam	I
<i>Begonia trichocarpa</i> Dalz.	BEGONIACEAE	Western Ghats, South West India	V
<i>Begonia watti</i> Clarke	BEGONIACEAE	Nagaland	E or Possibly Extinct
<i>Begonia wengeri</i> C.E.C. Fischer	BEGONIACEAE	Mizoram	I
<i>Berberis affinis</i> G. Don	BERBERIDACEAE	Uttar Pradesh (Kumaon)	R
<i>Berberis apiculata</i> (Ahrendt) Ahrendt	BERBERIDACEAE	Himachal Pradesh	R
<i>Berberis huegeliana</i> Schneid.	BERBERIDACEAE	Jammu & Kashmir	I
<i>Berberis kashmiriana</i> Ahrendt	BERBERIDACEAE	Jammu & Kashmir	R
<i>Berberis lambertii</i> Parker	BERBERIDACEAE	Uttar Pradesh (Kumaon)	V or E
<i>Berberis osmastonii</i> Dunn	BERBERIDACEAE	Uttar Pradesh (Garhwal)	R
<i>Bombax insigne</i> Wall. var. <i>polystemon</i> Prain	BOMBACACEAE	Narcondam Islands	I
<i>Poeciloneuron pauciflorum</i> Bedd.	BONNETIACEAE	Travancore, Tirunelveli hills	I

NOTES

<i>Heliotropium calcareum</i> Stocks	BORAGINACEAE	Gujarat, Rajasthan, Maharashtra	R
<i>Erysimum thomsonii</i> Hook. f.	BRASSICACEAE	Himachal Pradesh	R
<i>Campanula alphonisii</i> Wall. ex DC.	CAMPANULACEAE	Nilgiri and Pulney Hills, Western Ghats	R
<i>Campanula wattiana</i> Nayar et Babu	CAMPANULACEAE	Himachal Pradesh, Uttar Pradesh	R
<i>Codonopsis affinis</i> Hook. f. et Thoms.	CAMPANULACEAE	West Bengal	R
<i>Cyananthus integra</i> Wall. ex Benth.	CAMPANULACEAE	Tehri Garhwal	R
<i>Capparis cinerea</i> Jacobs	CAPPARACEAE	Manipur	I
<i>Capparis diversifolia</i> Wight & Arn.	CAPPARACEAE	Tamil Nadu	V
<i>Capparis fusifera</i> Dunn	CAPPARACEAE	Kerala, Tamil Nadu	R
<i>Capparis pachyphylla</i> Jacobs	CAPPARACEAE	North East India	I
<i>Capparis rheedii</i> DC.	CAPPARACEAE	Tamil Nadu, North Kanara	R
<i>Capparis shevaroyensis</i> Sundararaghavan	CAPPARACEAE	Tamil Nadu	V
<i>Cleome burmanni</i> Wight et Arn.	CAPPARACEAE	Tamil Nadu, Kerala	I
<i>Arenaria curvifolia</i> Majumdar	CARYOPHYLLACEAE	Uttar Pradesh (Garhwal)	E
<i>Arenaria ferruginea</i> Duthie ex Williams	CARYOPHYLLACEAE	Uttar Pradesh (Kumaon)	E
<i>Arenaria thangoensis</i> Smith	CARYOPHYLLACEAE	Sikkim	V
<i>Polycarpha diffusa</i> Wight & Arn.	CARYOPHYLLACEAE	Tamil Nadu	V
<i>Silene khasiana</i> Rohrb.	CARYOPHYLLACEAE	Meghalaya	I
<i>Silene kumaonensis</i> Williams	CARYOPHYLLACEAE	Uttar Pradesh (Garhwal)	R
<i>Silene kunawarensis</i> Royle	CARYOPHYLLACEAE	Jammu & Kashmir, Himachal Pradesh	R
<i>Silene vagans</i> Clarke	CARYOPHYLLACEAE	Nagaland	I
<i>Euonymus angulatus</i> Wight	CELASTRACEAE	Karnataka, Tamil Nadu, Kerala	E
<i>Euonymus assamicus</i> Blakelock	CELASTRACEAE	Assam	E
<i>Euonymus serratifolius</i> Bedd.	CELASTRACEAE	Tamil Nadu	E or Possibly

NOTES

			Extinct
<i>Salacia beddomei</i> Gamble	CELASTRACEAE	Tamil Nadu, Kerala	R
<i>Salacia jenkinsii</i> Kurz	CELASTRACEAE	Assam	E
<i>Salacia malabarica</i> Gamble	CELASTRACEAE	Karnataka, Kerala	E or Possibly Extinct
<i>Christensenia assamica</i> (Griff.) Ching	CHRISTENSENIACEAE	Assam	V
<i>Atuna travancorica</i> (Bedd.) Kosterm.	CHRYSOBALANACEAE	Travancore hills	I
<i>Garcinia cadelliana</i> King	CLUSIACEAE	South Andaman Island	I
<i>Garcinia kingii</i> Pierre ex Vesque	CLUSIACEAE	Andaman Island	I
<i>Garcinia manii</i> (King) Kosterm.	CLUSIACEAE	South Andaman Island	I
<i>Anogeissus sericea</i> Brandis var. <i>nummularia</i> King ex Duthie	COMBRETACEAE	Gujarat, Punjab, Rajasthan	R
<i>Aneilema glanduliferum</i> Joseph et Rolla Rao	COMMELINACEAE	Arunachal Pradesh	V
<i>Belosynapsis kewensis</i> Hassk.	COMMELINACEAE	Tamil Nadu	E
<i>Belosynapsis vivipara</i> (Dalz.) Sprague et Fischer	COMMELINACEAE	Sahyadri Hills, Western Ghats	V
<i>Commelina hirsuta</i> (Wight) Clarke	COMMELINACEAE	Nilgiri and Pulney Hills	R
<i>Commelina indehiscens</i> Barnes	COMMELINACEAE	Karnataka, Kerala, Tamil Nadu	R
<i>Commelina tricolor</i> Barnes	COMMELINACEAE	Tamil Nadu	V
<i>Commelina wightii</i> Rolla Rao	COMMELINACEAE	Tamil Nadu	V
<i>Cyanotis burmanniana</i> Wight	COMMELINACEAE	Western coastal region	R
<i>Cyanotis cerifolia</i> Rolla Rao et Kammathy	COMMELINACEAE	Tamil Nadu	I
<i>Dictyospermum ovalifolium</i> Wight	COMMELINACEAE	Kerala	R
<i>Murdannia juncoides</i> (Wight) Rolla Rao et Kammathy	COMMELINACEAE	Thenmalai (Western Ghats)	R
<i>Murdannia lanceolata</i> (Wight) Kammathy	COMMELINACEAE	Tamil Nadu, Kerala	V
<i>Murdannia lanuginosa</i> (Wall. ex Clarke) Bruckn.	COMMELINACEAE	Deccan Plateau, Sahyadri hills	R
<i>Pollia pentasperma</i> Clarke	COMMELINACEAE	Meghalaya, Nagaland	I
<i>Ipomoea clarkei</i> Hook. f.	CONVOLVULACEAE	Maharashtra	R
<i>Kalanchoe olivacea</i> Dalz.	CRASSULACEAE	Tamil Nadu	R
<i>Kalanchoe roseus</i> Clarke	CRASSULACEAE	Nagaland, Manipur	E
<i>Cyathea nilgirensis</i> Holtt.	CYATHEACEAE	Southern India	E

NOTES

<i>Sphaeropteris albosetacea</i> (Bedd.) Tryon [<i>Cyathea albosetacea</i> (Bedd.) Copel.]	CYATHEACEAE	Nicobar Islands	V
<i>Sphaeropteris crinita</i> (Hook.) Tryon [<i>Cyathea crinita</i> (Hook.) Copel.]	CYATHEACEAE	Tamil Nadu, Kerala	E
<i>Cycas beddomei</i> Dyer	CYCADACEAE	Andhra Pradesh	V
<i>Carex christii</i> Boeck.	CYPERACEAE	Tamil Nadu	I or Possibly Extinct
<i>Carex fuscifructus</i> Clarke	CYPERACEAE	Assam	I
<i>Carex kingiana</i> Clarke	CYPERACEAE	Sikkim	I
<i>Carex munroi</i> Clarke	CYPERACEAE	Himachal Pradesh	I
<i>Carex pseudoaperta</i> Kuekenth.	CYPERACEAE	Tamil Nadu	I
<i>Carex repanda</i> Clarke	CYPERACEAE	Meghalaya	Ex
<i>Carex vicinalis</i> Boott	CYPERACEAE	Tamil Nadu	I
<i>Cyperus dwarkensis</i> Sahni et Naithani	CYPERACEAE	Gujarat	R
<i>Fimbristylis stolonifera</i> Clarke	CYPERACEAE	Meghalaya	R
<i>Microschoenus duthiei</i> Clarke	CYPERACEAE	Uttar Pradesh (Tehri Garhwal)	I
<i>Rhynchospora submarginata</i> Keukenth.	CYPERACEAE	Kerala	I
<i>Scleria alta</i> Boeck.	CYPERACEAE	Assam, Meghalaya	I
<i>Dennstaedtia elwesii</i> (Bak.) Bedd.	DENNSTAEDTIACEAE	Sikkim	Possibly Extinct
<i>Dicranopteris linearis</i> (Burm. f.) Underw. var. <i>sebastiana</i> Panigr. & Dixit	DICRANOPTERIDACEAE	Tamil Nadu	V
<i>Dioscorea deltoidea</i> Wall. ex Kunth	DIOSCOREACEAE	Kashmir to Assam	V
<i>Dioscorea rogersii</i> Prain & Burk.	DIOSCOREACEAE	Andaman Islands	I
<i>Hopea jacobi</i> Fischer	DIPTEROCARPACEAE	Karnataka	R
<i>Vateria macrocarpa</i> B.L. Gupta	DIPTEROCARPACEAE	Kerala	R
<i>Elaeagnus conferta</i> Roxb. ssp. <i>dendroidea</i> Servettaz	ELAEAGNACEAE	Meghalaya	E
<i>Elaeocarpus acuminatus</i> Wall. ex Mast.	ELAEOCARPACEAE	Meghalaya	R
<i>Elaeocarpus blascoi</i> Weibel	ELAEOCARPACEAE	Tamil Nadu	R
<i>Elaeocarpus gausseii</i> Weibel	ELAEOCARPACEAE	Western Ghats	R
<i>Elaeocarpus munronii</i> (Wt.) Mast.	ELAEOCARPACEAE	Tamil Nadu, Karnataka, Maharashtra	R
<i>Elaeocarpus prunifolius</i> (C. Muell.) Mast.	ELAEOCARPACEAE	Meghalaya	R
<i>Elaeocarpus recurvatus</i> Corner	ELAEOCARPACEAE	Tamil Nadu	R
<i>Elaeocarpus venustus</i> Bedd.	ELAEOCARPACEAE	W. Ghats	V
<i>Elaphoglossum beddomei</i> Sledge	ELAPHOGLOSSACEAE	Anamalai & Nilgiri hills	R

NOTES

<i>Elaphoglossum nilgircum</i> Krajina ex Sledge	ELAPHOGLOSSACEAE	Tamil Nadu	E
<i>Elaphoglossum stigmatolepis</i> (Fee) Moore	ELAPHOGLOSSACEAE	Nilgiri hills	V
<i>Eriocaulon humile</i> Moldenke	ERIOCAULACEAE	Maharashtra	V
<i>Bridelia kurzii</i> Hook. f.	EUPHORBIACEAE	Andaman & Nicobar Islands	V
<i>Dalechampia stenoloba</i> Sundararaghavan et Kulkarni	EUPHORBIACEAE	Karnataka	R
<i>Drypetes andamanica</i> (Kurz) Pax & Hoffm.	EUPHORBIACEAE	S. Andaman Island	R
<i>Euphorbia katrajensis</i> Gage	EUPHORBIACEAE	Maharashtra	R
<i>Euphorbia panchganiensis</i> Blatt. & McCann	EUPHORBIACEAE	Maharashtra	R
<i>Phyllanthus narayanaswamii</i> Gamble	EUPHORBIACEAE	Andhra Pradesh	E
<i>Phyllanthus talbotii</i> Sedgw.	EUPHORBIACEAE	Karnataka	R
<i>Pseudoglochidion anamalayanum</i> Gamble	EUPHORBIACEAE	Tamil Nadu	I
<i>Acacia campbellii</i> Arn.	FABACEAE	Andhra Pradesh	R
<i>Albizia thompsonii</i> Brandis	FABACEAE	Andhra Pradesh, Tamil Nadu, Orissa	R
<i>Crotalaria clavata</i> Wight et Arn.	FABACEAE	Tamil Nadu	E
<i>Crotalaria digitata</i> Hook.	FABACEAE	Tamil Nadu	R
<i>Crotalaria filipes</i> Benth. var. <i>trichophora</i> (Benth. ex Baker) Cooke	FABACEAE	Maharashtra	R
<i>Crotalaria fysonii</i> Dunn var. <i>glabra</i> Gamble	FABACEAE	Tamil Nadu	E
<i>Crotalaria globosa</i> Wight et Arn.	FABACEAE	Tamil Nadu, Karnataka	R
<i>Crotalaria kodaiensis</i> Debberm. et Biswas	FABACEAE	Tamil Nadu	E
<i>Crotalaria longipes</i> Wight et Arn.	FABACEAE	Tamil Nadu	E
<i>Crotalaria lutescens</i> Dalz.	FABACEAE	Karnataka, Maharashtra	R
<i>Crotalaria meeboldii</i> Dunn	FABACEAE	Nagaland	I
<i>Crotalaria noveoides</i> Griff.	FABACEAE	Meghalaya	I
<i>Crotalaria peduncularis</i> Grah. ex Wight et Arn.	FABACEAE	Tamil Nadu, Kerala	R
<i>Crotalaria priesleyoides</i> Benth. ex Baker	FABACEAE	Tamil Nadu	R
<i>Crotalaria rigida</i> Heyne ex Roth	FABACEAE	Tamil Nadu, Karnataka	R
<i>Crotalaria sandoorensis</i> Bedd. ex Gamble	FABACEAE	Karnataka	E
<i>Crotalaria scabra</i> Gamble	FABACEAE	Tamil Nadu	R
<i>Crotalaria stocksii</i> Benth. ex Baker	FABACEAE	Maharashtra, Andaman Island	R
<i>Cynometra beddomei</i> Prain	FABACEAE	Kerala	I
<i>Cynometra bourdillonii</i> Gamble	FABACEAE	Karnataka	V
<i>Cynometra travancorica</i> Bedd.	FABACEAE	Karnataka	R
<i>Dialium travancoricum</i> Bourd.	FABACEAE	Kerala	I

NOTES

<i>Eleiotis trifoliolata</i> Cooke	FABACEAE	Karnataka	R
<i>Flemingia gracilis</i> (Mukherjee) Ali	FABACEAE	Maharashtra , Karnataka	R
<i>Gleditsia assamica</i> Bor	FABACEAE	Arunachal Pradesh, Meghalaya, Nagaland	I
<i>Hedysarum astragaloides</i> Benth. ex Baker	FABACEAE	Jammu & Kashmir, Himachal Pradesh	R
<i>Hedysarum cachemirianum</i> Benth. ex Baker	FABACEAE	Jammu & Kashmir	R or Possibly Vulnerable
<i>Hedysarum microcalyx</i> Baker	FABACEAE	Jammu & Kashmir, Himachal Pradesh	V
<i>Humboldtia bourdilloni</i> Prain	FABACEAE	Tamil Nadu, Kerala	E
<i>Humboldtia decurrens</i> Bedd. ex Oliver	FABACEAE	Tamil Nadu	R
<i>Humboldtia laurifolia</i> Vahl	FABACEAE	Kerala	E
<i>Humboldtia unijuga</i> var. <i>unijuga</i> Bedd.	FABACEAE	Tamil Nadu, Kerala	E
<i>Indigofera barberi</i> Gamble	FABACEAE	Andhra Pradesh, Tamil Nadu	R
<i>Indigofera caerulea</i> Roxb. var. <i>monosperma</i> (Sant.) Sant.	FABACEAE	Gujarat, Rajasthan	R
<i>Indigofera constricta</i> (Thw.) Trimen	FABACEAE	Goa, Karnataka, Kerala	R
<i>Inga cynometroides</i> (Bedd.) Bedd. ex Baker	FABACEAE	Kerala	I
<i>Kingiodendron pinnatum</i> (Roxb. ex DC.) Harms	FABACEAE	Karnataka, Tamil Nadu, Kerala	R
<i>Nogra dalzellii</i> (Baker) Merr.	FABACEAE	Maharashtra , Karnataka	V
<i>Nogra filicaulis</i> (Kurz) Merr.	FABACEAE	Madhya Pradesh	E
<i>Pueraria bella</i> Prain	FABACEAE	Arunachal Pradesh	R
<i>Rhynchosia beddomei</i> Baker	FABACEAE	Karnataka	R
<i>Rhynchosia velutina</i> Wight et Arn.	FABACEAE	Tamil Nadu	V
<i>Smithia agharkarii</i> Hemadri	FABACEAE	Maharashtra	R
<i>Tephrosia barberi</i> Drumm.	FABACEAE	Tamil Nadu	R
<i>Tephrosia calophylla</i> Bedd.	FABACEAE	Tamil Nadu, Karnataka	R
<i>Tephrosia jamnagerensis</i> Sant.	FABACEAE	Gujarat	R
<i>Tephrosia wynaadensis</i> Drumm.	FABACEAE	Kerala	R
<i>Vigna khandalensis</i> (Sant.) Raghavan & Wadhwa	FABACEAE	Maharashtra	R
<i>Hydnocarpus macrocarpa</i> (Bedd.)	FLACOURTIACEAE	Tamil Nadu,	E

NOTES

<i>Warb. ssp. macrocarpa</i>		Kerala	
<i>Didymocarpus missionis</i> Wall. ex R. Br.	GESNERIACEAE	Tamil Nadu	R
<i>Rhynchoglossum lazulinum</i> Rao & Joseph	GESNERIACEAE	Arunachal Pradesh	R
<i>Hippocratea andamanica</i> King	HIPPOCRATEACEAE	South Andaman Islands	R
<i>Mecodium levingei</i> (Clarke) Copel.	HYMENOPHYLLACEAE	Sikkim	R
<i>Gomphandra comosa</i> King	ICACINACEAE	Andaman & Nicobar Islands	R
<i>Ixonanthes khasiana</i> Hook. f.	IXONANTHACEAE	Meghalaya, Assam	V
<i>Juncus sikkimensis</i> Hook. f.	JUNCACEAE	Sikkim	R
<i>Acrocephalus palniensis</i> Mukherjee	LAMIACEAE	Tamil Nadu	I
<i>Anisochilus argenteus</i> Gamble	LAMIACEAE	S. India	V
<i>Anisochilus wightii</i> Hook. f.	LAMIACEAE	Tamil Nadu	R
<i>Leucas angustissima</i> Sedgw.	LAMIACEAE	Karnataka	R
<i>Leucas mukerjiana</i> Subba Rao et Kumari	LAMIACEAE	Andhra Pradesh	E
<i>Plectranthus bishopianus</i> Gamble	LAMIACEAE	Tamil Nadu	Possibly Extinct
<i>Plectranthus bourneae</i> Gamble	LAMIACEAE	Tamil Nadu	I
<i>Pogostemon atropurpureus</i> Benth.	LAMIACEAE	Tamil Nadu, Kerala	R
<i>Pogostemon nilagiricus</i> Gamble	LAMIACEAE	Nilgiri hills of Western Ghats	E
<i>Pogostemon paludosus</i> Benth.	LAMIACEAE	Tamil Nadu	E
<i>Pogostemon travancoricus</i> Bedd. var. <i>travancoricus</i>	LAMIACEAE	Kerala	R
<i>Scutellaria andamanica</i> Prain	LAMIACEAE	Andaman Islands	R
<i>Teucrium plectranthoides</i> Gamble	LAMIACEAE	Tirunelveli hills, Western Ghats	V
<i>Actinodaphne bourneae</i> Gamble	LAURACEAE	Tamil Nadu	E
<i>Actinodaphne lanata</i> Meisner	LAURACEAE	Tamil Nadu	E
<i>Actinodaphne lawsonii</i> Gamble	LAURACEAE	Tamil Nadu, Kerala	R
<i>Cryptocarya ferrarsii</i> King	LAURACEAE	Middle Andaman Island	I
<i>Litsea leiantha</i> (Kurz) Hook. f.	LAURACEAE	South Andaman Island	V
<i>Chlorophytum borivilianum</i> Sant. et Fernand.	LILIACEAE	Gujarat, Maharashtra	R
<i>Dipcadi concanense</i> (Dalz.) Baker	LILIACEAE	S. India	Possibly Extinct
<i>Dipcadi maharashtrensis</i> Deb et Dasgupta	LILIACEAE	Maharashtra	E
<i>Dipcadi minor</i> Hook. f.	LILIACEAE	Deccan Plateau	I
<i>Dipcadi reidii</i> Deb et Dasgupta	LILIACEAE	Western Himalaya	Presumed Extinct

NOTES

<i>Dipcadi saxorum</i> Blatt.	LILIACEAE	Maharashtra	V
<i>Dipcadi ursulae</i> Blatt.	LILIACEAE	Maharashtra	V
<i>Drimia razii</i> Ansari	LILIACEAE	Maharashtra	R
<i>Eremurus hamalaicus</i> Baker	LILIACEAE	Jammu & Kashmir, Himachal Pradesh	R
<i>Iphigenia magnifica</i> Ansari et Rolla Rao	LILIACEAE	Maharashtra, Karnataka	V
<i>Iphigenia sahyadrica</i> Ansari et Rolla Rao	LILIACEAE	Karnataka	E
<i>Iphigenia stellata</i> Blatt.	LILIACEAE	Maharashtra	V
<i>Lilium macklineae</i> Sealy	LILIACEAE	Manipur	E
<i>Lloydia himalensis</i> Royle	LILIACEAE	Jammu & Kashmir, Himachal Pradesh, Sikkim	R
<i>Nomocharis synaptica</i> Sealy	LILIACEAE	Arunachal Pradesh	R
<i>Scilla viridis</i> Blatt. et Hallb.	LILIACEAE	Maharashtra	E
<i>Urginea cogesta</i> Wight	LILIACEAE	S. India	E
<i>Urginea polyphylla</i> Hook. f.	LILIACEAE	Deccan Peninsula	Presumed Extinct
<i>Hugonia belli</i> Sedgw.	LINACEAE	Karnataka, Kerala	
<i>Lindsaea himalaica</i> Kramer	LINDSAEACEAE	Eastern India	R
<i>Lindsaea malabarica</i> (Bedd.) Bak. ex Christ.	LINDSAEACEAE	S. India, Madhya Pradesh	R
<i>Viscum mysorensense</i> Gamble	LORANTHACEAE	Karnataka	I
<i>Ammania desertorum</i> Blatt. & Hallb.	LYTHRACEAE	Gujarat, Rajasthan	R
<i>Lagerstroemia minuticarpa</i> Debberm. ex P.C. Kanjilal	LYTHRACEAE	Assam, Sikkim	R
<i>Rotala ritchiei</i> (C.B. Clarke) Koehne	LYTHRACEAE	Maharashtra	V
<i>Michelia punduana</i> Hook. f. et Thoms.	MAGNOLIACEAE	Meghalaya, Nagaland	R
<i>Aspidopteris canarensis</i> Dalz.	MALPIGHIACEAE	Karnataka, Kerala, Maharashtra	R
<i>Aspidopteris oxyphylla</i> (Wall.) Juss.	MALPIGHIACEAE	Meghalaya	I
<i>Aspidopteris tomentosa</i> var. <i>hutchinsonii</i> (Haines) Srivastava	MALPIGHIACEAE	Orissa	R
<i>Abutilon ranadei</i> Woodr. et Stapf	MALVACEAE	Maharashtra	E or Presumed Extinct
<i>Decaschistia rufa</i> Craib	MALVACEAE	Peninsular India	E
<i>Decaschistia trilobata</i> Wight	MALVACEAE	Peninsular	R

NOTES

		India	
<i>Kendrickia walker (Wight) Hook. f. ex Triana</i>	MELASTOMATACEAE	Tamil Nadu	E
<i>Memecylon flavescens Gamble</i>	MELASTOMATACEAE	Tamil Nadu	E
<i>Memecylon sisparens Gamble</i>	MELASTOMATACEAE	Tamil Nadu	I
<i>Aglaia talbotii Sundararaghavan</i>	MELIACEAE	Karnataka, Goa	V
<i>Albertisia mecistophylla (Miers) Forman</i>	MENISPERMACEAE	Assam, Meghalaya	I or Possibly Extinct
<i>Cyclea debiliflora Miers</i>	MENISPERMACEAE	Meghalaya	I or Possibly Extinct
<i>Cyclea fissicalyx Dunn</i>	MENISPERMACEAE	Kerala	Insufficiently Known
<i>Cyclea wattii Diels</i>	MENISPERMACEAE	Nagaland	I or Possibly Extinct
<i>Stephania andamanica Diels</i>	MENISPERMACEAE	South Andaman	I
<i>Mitrastemon yamamotoi (Makino) Makino</i>	MITRASTEMONACEAE	Meghalaya	E
<i>Ficus andamanica Corner</i>	MORACEAE	South Andaman Island	R
<i>Antistrophe serratifolia (Bedd.) Hook. f.</i>	MYRSINACEAE	Tamil Nadu, Kerala	R
<i>Eugenia argentea Bedd.</i>	MYRTACEAE	Kerala	E or Possibly Extinct
<i>Eugenia discifera Gamble</i>	MYRTACEAE	Tamil Nadu, Kerala	E
<i>Eugenia singampattiana Bedd.</i>	MYRTACEAE	Tamil Nadu	E or Possibly Extinct
<i>Meteoromyrtus wynaadensis (Bedd.) Gamble</i>	MYRTACEAE	Tamil Nadu, Kerala	E
<i>Syzygium andamanicum (King) Balakr.</i>	MYRTACEAE	Andaman Islands	I
<i>Syzygium bourdillonii (Gamble) Rathakr. et N.C. Nair</i>	MYRTACEAE	Kerala	E or Possibly Extinct
<i>Syzygium courtallense (Gamble) Alston</i>	MYRTACEAE	Tamil Nadu	E
<i>Syzygium gambleanum Rathakr. et Chitra</i>	MYRTACEAE	Tamil Nadu	E
<i>Syzygium manii (King) Balakr.</i>	MYRTACEAE	Middle Andaman Island	R
<i>Syzygium palghatense Gamble</i>	MYRTACEAE	Kerala	E or Possibly Extinct
<i>Syzygium travancoricum Gamble</i>	MYRTACEAE	Kerala	E
<i>Jasminum unifoliolatum Balakr. & N.G. Nair</i>	OLEACEAE	North Andaman Island	R
<i>Anoectochilus nicobaricus Balakr. et P. Chakarab.</i>	ORCHIDACEAE	Great Nicobar Island	E
<i>Anoectochilus rotundifolius (Blatt.) Balakr.</i>	ORCHIDACEAE	Tamil Nadu	E or Possibly Extinct

NOTES

<i>Anoectochilus tetrapterus</i> Hook. f.	ORCHIDACEAE	Manipur	V or Possibly Endangered
<i>Aphyllorchis gollani</i> Duthie	ORCHIDACEAE	Uttar Pradesh (Tehri Garhwal)	E or Possibly Extinct
<i>Aphyllorchis parviflora</i> King & Pantl.	ORCHIDACEAE	Uttar Pradesh (Garhwal)	R
<i>Archineottia microglottis</i> (Duthie) Chen	ORCHIDACEAE	Uttar Pradesh (Garhwal)	R
<i>Bulbophyllum acutiflorum</i> A. Rich.	ORCHIDACEAE	Tamil Nadu	R
<i>Bulbophyllum albidum</i> Hook. f.	ORCHIDACEAE	Tamil Nadu	R
<i>Bulbophyllum aureum</i> (Hook. f.) J.J. Sm.	ORCHIDACEAE	Kerala	R
<i>Bulbophyllum elegantulum</i> (Rolfe) J.J. Sm.	ORCHIDACEAE	Karnataka	V
<i>Bulbophyllum kaitiense</i> (Wight) Reichb. f. Duthie	ORCHIDACEAE	Nilgiris	V
<i>Bulleyia yunnanensis</i> Schltr.	ORCHIDACEAE	Arunachal Pradesh, West Bengal	R
<i>Calanthe alpina</i> Hook. f. ex Lindl.	ORCHIDACEAE	Uttar Pradesh (Garhwal)	R
<i>Calanthe anthropophora</i> Ridley	ORCHIDACEAE	Meghalaya	E
<i>Calanthe mannii</i> Hook. f.	ORCHIDACEAE	Arunachal Pradesh, Uttar Pradesh (Garhwal), Sikkim	R
<i>Calanthe pachystalix</i> Reichb. f. ex Hook. f.	ORCHIDACEAE	Himachal Pradesh, Uttar Pradesh (Mussoorie)	E
<i>Chrysoglossum hallbergii</i> Blatt.	ORCHIDACEAE	Peninsular India (Tamil Nadu)	I or Insufficientl y Known
<i>Coelogyne mossiae</i> Rolfe	ORCHIDACEAE	Peninsular India	V
<i>Coelogyne rossiana</i> Reichb. f.	ORCHIDACEAE	Assam, Mizoram	V
<i>Coelogyne treutleri</i> Hook. f.	ORCHIDACEAE	Sikkim	Possibly Extinct
<i>Corybus purpureus</i> Joseph et Yog.	ORCHIDACEAE	Meghalaya	R
<i>Corymborkis veratifolia</i> (Reinw.) Bl.	ORCHIDACEAE	Tamil Nadu	R
<i>Cymbidium eburneum</i> Lindl.	ORCHIDACEAE	Arunachal Pradesh, Manipur, Meghalaya, Nagaland,	V

NOTES

		Sikkim	
<i>Cymbidium hookerianum</i> Reichb. f.	ORCHIDACEAE	Uttar Pradesh (Kumaon), Arunachal Pradesh, Sikkim	V
<i>Cymbidium tigrinum</i> Parish	ORCHIDACEAE	Nagaland	R
<i>Cymbidium whiteae</i> King & Pantl.	ORCHIDACEAE	N.E. Himalaya, Sikkim	E
<i>Cypripedium cordigerum</i> D. Don	ORCHIDACEAE	Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh (Garhwal)	R
<i>Cypripedium elegans</i> Reichb. f.	ORCHIDACEAE	Sikkim, Uttar Pradesh (Garhwal)	R
<i>Cypripedium himalaicum</i> Rolfe	ORCHIDACEAE	Sikkim, Uttar Pradesh (Garhwal, Kumaon)	R
<i>Dendrobium arachnites</i> Reichb. f.	ORCHIDACEAE	India	V
<i>Dendrobium aurantiacum</i> Reichb. f.	ORCHIDACEAE	Assam	E
<i>Dendrobium tenuicaule</i> Hook. f.	ORCHIDACEAE	Middle Andaman Island	E
<i>Didickea cunninghamii</i> King et Prain ex King et Pantl.	ORCHIDACEAE	Sikkim, Uttar Pradesh (Garhwal)	E
<i>Diplomeris hirsuta</i> (Lindl.) Lindl.	ORCHIDACEAE	Uttar Pradesh (Kumaon), West Bengal	V
<i>Diplomeris pulchella</i> D. Don	ORCHIDACEAE	Meghalaya, Arunachal Pradesh	V
<i>Eria albiflora</i> Rolfe	ORCHIDACEAE	Tamil Nadu, Kerala, Karnataka	R
<i>Eria occidentalis</i> Seid.	ORCHIDACEAE	Uttar Pradesh (Kumaon)	R
<i>Eulophia mackinnonii</i> Duthie	ORCHIDACEAE	Uttar Pradesh, Madhya Pradesh	R
<i>Eulophia nicobarica</i> Balakr. & N.G. Nair	ORCHIDACEAE	Nicobar Islands	E
<i>Flickingeria hesperis</i> Seid.	ORCHIDACEAE	Uttar Pradesh (Kumaon)	E
<i>Habenaria andamanica</i> Hook. f.	ORCHIDACEAE	South Andaman	R

NOTES

		Island	
<i>Habenaria barnesii</i> Summerh.	ORCHIDACEAE	Tamil Nadu, Kerala	R
<i>Habenaria panchgeniensis</i> Sant. & Kapad.	ORCHIDACEAE	Maharashtra	R
<i>Ipsea malabarica</i> (Reichb. f.) Hook. f.	ORCHIDACEAE	Kerala	E
<i>Liparis biloba</i> Wight	ORCHIDACEAE	Tamil Nadu	V
<i>Malleola andamanica</i> Balakr. & Bhargava	ORCHIDACEAE	Andaman Islands	E
<i>Neottia inayatii</i> (Duthie) Beauv.	ORCHIDACEAE	Jammu & Kashmir	R
<i>Oberonia brachyphylla</i> Blatt. & McCann	ORCHIDACEAE	Karnataka, Kerala	R
<i>Paphiopedilum druryi</i> (Bedd.) Stein	ORCHIDACEAE	Kerala	E or Possibly Extinct
<i>Paphiopedilum fairrieianum</i> (Lindl.) Stein	ORCHIDACEAE	Sikkim, Arunachal Pradesh	E
<i>Paphiopedilum hirsutissimum</i> (Lindl. ex Hook.) Stein	ORCHIDACEAE	Meghalaya	R
<i>Paphiopedilum insigne</i> (Wall. ex Lindl.) Pfitz.	ORCHIDACEAE	Meghalaya	V
<i>Paphiopedilum specerianum</i> (Reichb. f.) Pfitz.	ORCHIDACEAE	Manipur	V
<i>Paphiopedilum venustum</i> (Wall. ex Sims.) Pfitz.	ORCHIDACEAE	Meghalaya, Sikkim	V
<i>Paphiopedilum villosum</i> (Lindl.) Stein	ORCHIDACEAE	Mizoram	V
<i>Paphiopedilum wardii</i> Summerh.	ORCHIDACEAE	Arunachal Pradesh	E
<i>Phalaenopsis speciosa</i> Reichb. f.	ORCHIDACEAE	Andaman & Nicobar Islands	E
<i>Pholidota wattii</i> King et Pantl.	ORCHIDACEAE	Arunachal Pradesh, Assam	R
<i>Pleione lagenaria</i> Lindl.	ORCHIDACEAE	Meghalaya	Presumed Extinct
<i>Renanthera imschootiana</i> Rolfe	ORCHIDACEAE	Manipur, Nagaland, Mizoram	E
<i>Taeniophyllum andamanicum</i> Balakr. & Bhargava	ORCHIDACEAE	Andaman Islands	E
<i>Vanda coerulea</i> Griff. ex Lindl.	ORCHIDACEAE	North East India	R
<i>Vanda wightii</i> Reichb. f.	ORCHIDACEAE	Tamil Nadu	Possibly Extinct
<i>Vanilla wightiana</i> Lindl.	ORCHIDACEAE	Tamil Nadu, Kerala	R
<i>Zeuxine pulchra</i> King et Pantl.	ORCHIDACEAE	Sikkim, Meghalaya	E or Possibly Extinct

NOTES

<i>Mecanopsis latifolia</i> (Prain) Prain	PAPAVERACEAE	Jammu & Kashmir	V
<i>Uleria salicifolia</i> Bedd.	PERIPLOCACEAE	Tamil Nadu, Kerala	E
<i>Piper barberi</i> Gamble	PIPERACEAE	Southern Western Ghats	R
<i>Pittosporum eriocarpum</i> Royle	PITTOSPORACEAE	Uttar Pradesh (Garhwal, Kumaon)	I
<i>Bhidea burnsiana</i> Bor	POACEAE	Maharashtra, Karnataka	R
<i>Coelachne minuta</i> Bor	POACEAE	Maharashtra	R
<i>Deyeuxia simlensis</i> Bor	POACEAE	Himachal Pradesh	Presumed Extinct
<i>Dicanthium armatum</i> (Hook. f.) Blatt. et McCann	POACEAE	Maharashtra	R
<i>Dicanthium compressum</i> (Hook. f.) Jain et Deshpande	POACEAE	Maharashtra	R
<i>Dicanthium maccannii</i> Blatt.	POACEAE	Maharashtra	V
<i>Dicanthium panchaganiensis</i> Blatt. et McCann	POACEAE	Maharashtra	R
<i>Dicanthium woodrowii</i> (Hook. f.) Jain et Deshpande	POACEAE	Maharashtra	V
<i>Dimeria blatteri</i> Bor	POACEAE	Maharashtra	R
<i>Dimeria woodrowii</i> Stapf	POACEAE	Maharashtra, Goa, Karnataka	R
<i>Eragrostis rottleri</i> Stapf	POACEAE	S. India	Presumed Extinct
<i>Eriochrysis rangacharii</i> Fischer	POACEAE	Tamil Nadu	Presumed Extinct
<i>Glyphochloa divergens</i> (Hook.) Clayton	POACEAE	Karnataka	R
<i>Glyphochloa santapau</i> (Jain et Deshpande) Clayton	POACEAE	Maharashtra	R
<i>Glyphochloa talbotii</i> (Hook. f.) Clayton	POACEAE	Goa, West coast of Peninsular India	V
<i>Hubbardia heptaneuron</i> Bor	POACEAE	Karnataka	Presumed Extinct
<i>Isachne borii</i> Hemadri	POACEAE	Maharashtra	R
<i>Isachne fischeri</i> Bor	POACEAE	Kerala	R
<i>Isachne lisboae</i> Hook. f.	POACEAE	Maharashtra, Karnataka	
<i>Isachne mysorensis</i> Raghavan	POACEAE	Karnataka	R
<i>Ischaemum raizadae</i> Hemadri et Billore	POACEAE	Maharashtra	R
<i>Limnopoa meeboldii</i> (Fischer) Hubb.	POACEAE	Kerala	V
<i>Puccinellia kashmiriana</i> Bor	POACEAE	Jammu & Kashmir, Himachal Pradesh	R
<i>Schizachyrium paranjpyeanum</i> (Bhide)	POACEAE	Maharashtra, Karnataka	R

NOTES

Raizada et Jain			
<i>Indotristicha tirunelveliana</i> Sharma, Karthi. & Shetty	PODOSTEMONACEAE	Tamil Nadu	R or V
<i>Willisia selaginoides</i> (Bedd.) Warm. ex Willis	PODOSTEMONACEAE	Kerala	R
<i>Christiopteris tricuspis</i> (Hook.) Christ.	POLYPODIACEAE	West Bengal	I
<i>Dendroglossa minutula</i> (Fee) Copel.	POLYPODIACEAE	Meghalaya	E
<i>Drynaria meeboldii</i> Rosenst.	POLYPODIACEAE	Manipur	V
<i>Polypodioides wattii</i> (Bedd.) Ching	POLYPODIACEAE	Eastern India	R
<i>Sapria himalayana</i> Griff.	RAFFLESACEAE	Arunachal Pradesh, Manipur, Meghalaya	R
<i>Aconitum deinorrhizum</i> Stapf	RANUNCULACEAE	Jammu & Kashmir, Himachal Pradesh	V
<i>Aconitum falconeri</i> Stapf var. <i>latilobum</i> Stapf	RANUNCULACEAE	Himachal Pradesh	V
<i>Aconitum ferox</i> Wall. ex Seringe	RANUNCULACEAE	Himachal Pradesh, Sikkim	V
<i>Clematis apiculata</i> Hook. f. et Thoms.	RANUNCULACEAE	Meghalaya	E
<i>Clematis bourdillonii</i> Dunn	RANUNCULACEAE	Kerala	V
<i>Clematis theobromina</i> Dunn	RANUNCULACEAE	Tamil Nadu	R
<i>Coptis teeta</i> Wall.	RANUNCULACEAE	Arunachal Pradesh	V
<i>Delphinium uncinatum</i> Hook. f. et Thoms.	RANUNCULACEAE	Jammu & Kashmir, Himachal Pradesh	V
<i>Thalictrum dalzellii</i> Hook.	RANUNCULACEAE	Karnataka, Maharashtra	I
<i>Cotoneaster buxifolius</i> Wall. ex Lindley	ROSACEAE	Tamil Nadu	V
<i>Cotoneaster simonsii</i> Hort. ex Baker	ROSACEAE	Sikkim	I
<i>Acranthera grandiflora</i> Bedd.	RUBIACEAE	Tamil Nadu	E
<i>Acranthera tomentosa</i> R. Br. ex Hook. f.	RUBIACEAE	Meghalaya, Assam, Nagaland	V
<i>Argostemma khasianum</i> Clarke	RUBIACEAE	Meghalaya	I
<i>Clarkella nana</i> (Edgew.) Hook. f.	RUBIACEAE	Western Himalaya	R
<i>Hedyotis albonervia</i> Bedd.	RUBIACEAE	Tamil Nadu	E
<i>Hedyotis barberi</i> (Gamble) Henry et Subramanyam	RUBIACEAE	Tamil Nadu	V
<i>Hedyotis beddomei</i> Hook. f.	RUBIACEAE	Kerala	E
<i>Hedyotis bourdillonii</i> (Gamble) Rolla Rao et Hemadri	RUBIACEAE	Kerala	V
<i>Hedyotis brunonis</i> Merr.	RUBIACEAE	West Bengal, Assam	R

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<i>Hedyotis buxifolia</i> Bedd.	RUBIACEAE	Tamil Nadu, Kerala	R
<i>Hedyotis cyanantha</i> Kurz	RUBIACEAE	Tamil Nadu, Maharashtra, Karnataka	R
<i>Hedyotis eualata</i> (Bedd. ex Gamble) Henry et Subramanyam	RUBIACEAE	Tamil Nadu, Kerala	R To p
<i>Hedyotis fruticosa</i> Linn.	RUBIACEAE	Travancore	R
<i>Hedyotis hirsutissima</i> Bedd.	RUBIACEAE	Tamil Nadu	Possibly Extinct
<i>Hedyotis ramarowii</i> (Gamble) Rolla Rao et Hemadri	RUBIACEAE	Tamil Nadu, Kerala	V
<i>Hedyotis scabra</i> Wall. ex Kurz	RUBIACEAE	West Bengal, Assam, Arunachal Pradesh	R
<i>Hedyotis swersoides</i> Hook. f.	RUBIACEAE	Tamil Nadu, Kerala	R
<i>Indopolysolenia wallichii</i> (Hook. f.) Bennet [<i>Polysolenia wallichii</i> Hook. f.]	RUBIACEAE	Meghalaya	R
<i>Nauclea gageana</i> King	RUBIACEAE	Andaman islands	I
<i>Neanotis carnosus</i> (Dalz.) Lewis	RUBIACEAE	Karnataka	I
<i>Neanotis oxyphylla</i> (G. Don) Lewis	RUBIACEAE	Meghalaya	R
<i>Neanotis prainiana</i> (Talbot) Lewis	RUBIACEAE	Karnataka	V
<i>Ochreinauclea missionis</i> (Wall. ex G. Don) Ridsd.	RUBIACEAE	Tamil Nadu, Kerala, Karnataka	V
<i>Ophiorrhiza barnesii</i> Fischer	RUBIACEAE	Kerala	Possibly Extinct
<i>Ophiorrhiza brunonis</i> Wight et Arn.	RUBIACEAE	Tamil Nadu, Kerala, Karnataka	Presumed Extinct
<i>Ophiorrhiza caudata</i> Fischer	RUBIACEAE	Kerala	Presumed Extinct
<i>Ophiorrhiza gracilis</i> Kurz	RUBIACEAE	Nagaland	I
<i>Ophiorrhiza griffithii</i> Hook. f.	RUBIACEAE	Nagaland	I
<i>Ophiorrhiza hispida</i> Hook. f.	RUBIACEAE	Meghalaya, Assam	E
<i>Ophiorrhiza incarnata</i> Fischer	RUBIACEAE	Kerala	E
<i>Ophiorrhiza lurida</i> Hook. f.	RUBIACEAE	Sikkim, West Bengal, Manipur	R
<i>Ophiorrhiza pykarensis</i> Gamble	RUBIACEAE	Nilgiri Hills	Possibly Extinct
<i>Ophiorrhiza radicans</i> Gardn.	RUBIACEAE	Kerala	Possibly Extinct
<i>Ophiorrhiza subcapitata</i> Wall. ex Hook. f.	RUBIACEAE	Meghalaya	E
<i>Ophiorrhiza tingens</i> Clarke ex Fischer	RUBIACEAE	Meghalaya, Assam, Tripura, Nagaland	V
<i>Ophiorrhiza wattii</i> Fischer	RUBIACEAE	Meghalaya, Nagaland,	E

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		Manipur	
<i>Pavetta hohenackeri</i> Brem.	RUBIACEAE	Tamil Nadu	V
<i>Pavetta oblanceolata</i> Brem.	RUBIACEAE	Kerala	I or Possibly Extinct
<i>Pavetta wightii</i> Hook. f.	RUBIACEAE	Tamil Nadu	Possibly Extinct
<i>Prismatomeris andamanica</i> Ridley	RUBIACEAE	South Andaman Islands	I
<i>Psychotria andamanica</i> Kurz	RUBIACEAE	Andaman & Nicobar Islands	R
<i>Psychotria aborensis</i> Dunn	RUBIACEAE	Arunachal Pradesh	R
<i>Psychotria globicephala</i> Gamble	RUBIACEAE	Tamil Nadu	E
<i>Psychotria pendula</i> Hook. f.	RUBIACEAE	South Andaman Islands	I
<i>Psychotria tylophora</i> Kurz	RUBIACEAE	Nicobar islands	Possibly Extinct
<i>Rubia edgeworthii</i> Hook. f.	RUBIACEAE	Western Himalaya	V
<i>Rubia himalayensis</i> Klotzsch	RUBIACEAE	Jammu & Kashmir	V
<i>Tarenna agumbensis</i> Sundararaghavan	RUBIACEAE	Karnataka	V
<i>Wendlandia andamanica</i> Cowan	RUBIACEAE	Andaman Islands	E
<i>Wendlandia angustifolia</i> Wight ex Hook. f.	RUBIACEAE	Tamil Nadu	Presumed Extinct
<i>Glycosmis macrocarpa</i> Wight	RUTACEAE	Tamil Nadu, Kerala	R
<i>Melicope indica</i> Wight	RUTACEAE	Tamil Nadu	V
<i>Allophylus concanicus</i> Radlk.	SAPINDACEAE	Maharashtra	R
<i>Isonandra stocksii</i> Clarke	SAPOTACEAE	Western Peninsular India	V
<i>Isonandra villosa</i> Wight	SAPOTACEAE	Tamil Nadu, Kerala, Andhra Pradesh	I
<i>Madhuca bourdillonii</i> (Gamble) H.J. Lam	SAPOTACEAE	Kerala	Possibly Extinct
<i>Madhuca diplostemon</i> (Clarke) van Royen	SAPOTACEAE	Peninsular India	Insufficiently Known
<i>Madhuca insignis</i> (Radlk.) H.J. Lam	SAPOTACEAE	Karnataka	Possibly Extinct
<i>Palaquium bourdillonii</i> Brandis	SAPOTACEAE	Kerala	I
<i>Campylanthus ramosissimus</i> Wt.	SCROPHULARIACEAE	Gujarat	R
<i>Picrorhiza kurrooa</i> Royle ex Benth.	SCROPHULARIACEAE	Jammu & Kashmir to Sikkim	V
<i>Selaginella adunca</i> A. Br. ex Hieron.	SELAGINELLACEAE	North West Himalayas	E
<i>Selaginella catractrum</i> Alston	SELAGINELLACEAE	South India	E

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<i>Smilax wightii</i> A. DC.	SMILACACEAE	Tamil Nadu	R
<i>Paauia belladonna</i> Deb et Dutta	SOLANACEAE	Arunachal Pradesh	R
<i>Eriolaena lushingtonii</i> Dunn	STERCULIACEAE	Andhra Pradesh, Tamil Nadu	V
<i>Hildegardia populifolia</i> (Roxb.) Schott & Endl.	STERCULIACEAE	Andhra Pradesh, Tamil Nadu	E
<i>Pterospermum reticulatum</i> Wight & Arn.	STERCULIACEAE	Karnataka, Kerala, Tamil Nadu	R
<i>Sterculia khasiana</i> Debbarman	STERCULIACEAE	Meghalaya	Presumed Extinct
<i>Alniphyllum fortunei</i> (Hemsl.) Makino	STYRACACEAE	Arunachal Pradesh	R
<i>Huodendron biaristatum</i> (W.W. Sm.) Rehder	STYRACACEAE	Arunachal Pradesh	R
<i>Adinandra griffithii</i> Dyer	TERNSTROEMIAACEAE	Meghalaya	E
<i>Cleyera japonica</i> Thunb. var. <i>grandiflora</i> (Wall. ex Choisy) Kobuski	THEACEAE	Meghalaya	R
<i>Pyrenaria khasiana</i> R.N. Paul	THEACEAE	Meghalaya	I
<i>Christella clarkei</i> (Bedd.) Holtt.	THELYPTERIDACEAE	West Bengal, Sikkim	V
<i>Christella kaumaunica</i> Holtt.	THELYPTERIDACEAE	Uttar Pradesh (Kumaon)	V
<i>Coryphoteris didymochlaenoides</i> (Clarke) Holtt.	THELYPTERIDACEAE	Meghalaya	R
<i>Cyclogramma squamaestipes</i> (Clarke) Tagawa	THELYPTERIDACEAE	Sikkim	R
<i>Metathelypteris decipiens</i> (Clarke) Ching	THELYPTERIDACEAE	West Bengal, Meghalaya	R
<i>Oreopteris elwesii</i> (Bak.) Holtt.	THELYPTERIDACEAE	Sikkim	R
<i>Pronephrum thwaitesii</i> (Hook.) Holtt.	THELYPTERIDACEAE	Kerala	V
<i>Pseudocyclosorous gamblei</i> Holtt. & Grimes	THELYPTERIDACEAE	Nilgiri & Palni Hills	E
<i>Pseudocyclosorous griseus</i> (Baker) Holtt. & Grimes [<i>Neprodium griseum</i> Bake]	THELYPTERIDACEAE	Kerala, Tamil Nadu	E
<i>Stenogramme himalaica</i> (Ching) K. Iwats.	THELYPTERIDACEAE	North West Himalaya	V
<i>Erinocarpus nimmonii</i> Graham	TILIACEAE	Maharashtra, Karnataka	R
<i>Nardostachys grandiflora</i> DC.	VALERIANACEAE	Himachal Pradesh	V
<i>Ginalloa andamanica</i> Kurz	VISCACEAE	South Andaman Island	E
<i>Ampelocissus helferi</i> (Lawson) Planch.	VITACEAE	Andaman Islands	V
<i>Cayratia pedata</i> (lam.) Juss. ex Gagnepain var. <i>glabra</i> Gamble	VITACEAE	Nilgiri	R
<i>Cayratia roxburghii</i> (Wight et Arn.) Gagnepain	VITACEAE	Kerala, Tamil Nadu	V

<i>Cissus spectabilis</i> (Kurz) Planch.	VITACEAE	Sikkim, West Bengal	E
<i>Amomum microstephanum</i> Baker	ZINGIBERACEAE	Tamil Nadu, Kerala	R
<i>Paracautietya bhatii</i> Smith	ZINGIBERACEAE	Karnataka	V

Source: Nayar, M.P. & Sastry, A.R.K. 1990. Red Data Book of Indian Plants. Vol. 1-3. Botanical Survey of India, Calcutta.

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6.7 RED DATA BOOK

The Red Data Book is the state document established for documenting rare and endangered species of animals, plants and fungi as well as some local sub-species that exist within the territory of the state or country. The Red Data Book contains the complete list of threatened species. ... The Red Data Book contains colour-coded information sheets, which are arranged according to the extinction risk of many species and subspecies. Black represents species which are confirmed to be extinct.

Uses of Red Data Book

Red Data Book of the Russian Federation (RDBRF), also known as Red Book (Russian: Красная книга) or Russian Red Data Book is a state document established for documenting rare and endangered species of animals, plants and fungi, as well as some local subspecies (such as the Ladoga seal) that exist within the territory .

Types of Red Data Book

The Red List of 2012 was released 19 July 2012 at Rio+20 Earth Summit; nearly 2,000 species were added, with 4 species to the extinct list, 2 to the rediscovered list. The IUCN assessed a total of 63,837 species which revealed 19,817 are threatened with extinction.

Who publishes Red Data Book?

The third edition of Estonian Red Data Book has been published. This version, which is still valid today, has been compiled and published by the Nature Conservation Committee of the Estonian Academy of Sciences

IUCN prepare Red Data Book

The IUCN maintains a Red Data Book which contains a record of animals which are known to be in danger. It includes endangered, vulnerable, rare, extinct etc. species of plants and animals. It helps to create awareness about the various species

Difference between Red list and red data book

Red Data Book is the source **book** which keeps a record of all the endangered animals and plants there are **different books** for plants, animals and other species. ... The introduction in 1994 of a scientifically rigorous approach to determine risks of extinction that is applicable to all species, has become a world standard

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6.8 THREATENED ANIMALS OF INDIA

WWF-India's Threatened Species Conservation Programme includes the following species:

- Sarus crane
- Common leopard
- Great Indian bustard
- Himalayan quail
- House sparrow
- Nilgiri tahr
- Gharial
- Asiatic lion
- Ganges river dolphin
- Black-necked crane
- Smooth-coated otter
- Golden mahseer
- Indian pangolin
- Brow-antlered deer

Check your progress

1. What are threatened species? Give three categories of threatened species
2. Give an account of biogeographically regions of India
3. Name three endangered animal species of India
4. What are the threats of biodiversity?
5. Write short notes on Red list plants
6. Distinguish between endangered, critically endangered and vulnerable

6.9 LET US SUM UP

Vegetation types of India due to varied climatic conditions, it has a wide range of natural vegetation. Vegetation of India can be divided into five types – Tropical evergreen forest, Tropical deciduous forest, Thorny bushes, Mountain vegetation and Mangrove forests. Endemism is the ecological state of a species being unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type. Threatened species are divided into these categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable, and near threatened.

6.10 UNIT END EXERCISES

1. Vegetation of India and Tamilnadu
 2. Endemism and Red Data Book
 3. Biodiversity act of India
 - 4.
-

6.11 ANSWER TO CHECK YOUR PROGRESS

1

. Threatened species are any species which are vulnerable to endangerment in the near future. Species that are threatened are sometimes characterised by the population dynamics measure of critical depensation, a mathematical measure of biomass related to population growth rate. The International Union for Conservation of Nature (IUCN) is the foremost authority on threatened species, and treats threatened species not as a single category, but as a group of three categories, depending on the degree to which they are threatened:

2.

(c) Vulnerable species

(d) Endangered species

(e) Critically endangered species

3. There are ten biogeographic zones in India.

- Trans Himalayan **zone**.
- Himalayan **zone**.
- Desert **zone**.
- Semiarid **zone**.
- Western ghat **zone**.
- Deccan plateau **zone**.
- Gangetic plain **zone**.
- North east **zone**.

3. **Indian** elephant, Bengal tiger, **Indian** lion, **Indian** Rhino, Gaur, lion tailed macaque

5. **Biodiversity** is under serious **threat** as a result of human activities. The main dangers worldwide are population growth and resource consumption, climate change and global warming, habitat conversion and urbanisation, invasive alien species, over-exploitation of natural resources and environmental degradation.

6. The IUCN Red List of Threatened Species, founded in 1964, is the world's most comprehensive inventory of the global conservation status of biological species. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies.

7. **i.Vulnerable/Threatened** - These are species that face a high risk of extinction, but not for many years. These species are typically

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hunted for pelts and trophies - for example, lions for pelts and African elephants for ivory - or have lost a significant amount of their habitat, such as Komodo dragons and Galapagos tortoises.

ii.Endangered - These organisms face a high risk of extinction in the near future. Examples include Asian elephants, green sea turtles, and blue whales. These populations are closely monitored, and there are considerable fines and jail time if someone is found hunting or harming a species that is considered endangered.

iii.Critically Endangered - A species in this category is likely to go extinct in the near future unless drastic measures are taken to ensure its survival. Many of these species were over-hunted or over-fished and continue to be hunted illegally, also known as **poaching**. Examples include the mountain gorilla, bluefin tuna, and the California condor.

6.12 SUGGESTED READINGS

1. D.L. Hawskworth, 2009, Methods and Practice in Biodiversity Conservation, Springer, ISBN:9789048138487

UNIT – 7 BIODIVERSITY ACT OF INDIA 2002 AND 2004

Biodiversity Act of India 2002
and 2004

Structure

- 7.1 Introduction
- 7.2 Objectives
- 7.3 General overview of plant Conservation
- 7.4 Conservation of biodiversity
- 7.5 Wildlife Sanctuaries,
- 7.6 National parks
- 7.7 Biosphere Reserves,
- 7.8 Hotspot biodiversity areas in India-
- 7.9 Sustainable use of plant genetic resources,
- 7.10 Biotechnology assisted plant conservation (in *situ* and *ex situ* conservation).
- 7.11 Let us sum up
- 7.12 Unit end Exercises
- 7.13 Answer to check your progress
- 7.14 Suggested readings

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7.1 INTRODUCTION

An Act to provide for conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto.

The Biological Diversity Act, 2002 is an Act of the Parliament of India for preservation of biological diversity in India, and provides mechanism for equitable sharing of benefits arising out of the use of traditional biological resources and knowledge. The Act was enacted to meet the obligations under Convention on Biological Diversity (CBD), to which India is a party.

The Biological Diversity Act, 2002 (BD Act), that was enacted to meet India's international obligations under the Convention on Biological Diversity, has introduced two new concepts into the legal and normative framework governing biodiversity in India – 'access' and 'benefit sharing'. It regulates access to India's biological resources and associated knowledge and makes provision for sharing of benefits arising out of their utilization. However, this vital piece of legislation, which is the cornerstone of biodiversity governance in the country, especially on the fronts of sustainability and equity, unfortunately suffers from serious ambiguities in its regulatory as well as punitive mechanisms despite it being in existence for almost a decade and a dozen of cases having been brought under it before various dispute resolution forums.

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7.2 OBJECTIVES

- To regulate access to biological resources of the country;
- To conserve and sustainably use biological diversity;
- To respect and protect knowledge of local communities related to biodiversity;
- To secure sharing of benefits with local people as conservers of biological resources and holders of knowledge and information relating to the use of biological resources;
- Conservation and development of areas of importance from the standpoint of biological diversity by declaring them as biological diversity heritage sites;
- Protection and rehabilitation of threatened species;
- Involvement of institutions of state governments in the broad scheme of the implementation of the Biological Diversity Act through constitution of committees.

7.3 GENERAL OVERVIEW OF PLANT CONSERVATION

Plants are universally recognized as a vital component of the world's biological diversity and an essential resource for the planet. In addition to the cultivated plant species used for food, timber and fibres, many wild plants have great economic and cultural importance and potential, as future crops and commodities more so as humanity grapples with the emerging challenges of environmental and climate change. Plants play a key role in maintaining the planet's basic environmental balance and ecosystem stability and provide an irreplaceable component of the habitats for the world's animal life. At present, a complete inventory of the plants of the world has not been assembled, but it is estimated that the total number of vascular plant species may be of the order of 400,000. Of urgent concern is the fact that many plant species, communities, and their ecological interactions, including the many relationships between plant species and human communities and cultures, are in danger of extinction, threatened by such human-induced factors as, inter alia, climate change, habitat loss and transformation, over-exploitation, alien invasive species, pollution, clearing for agriculture and other development,. If this loss is not stemmed, countless opportunities to develop new solutions to pressing economic, social, health and industrial problems will also be lost. Furthermore, plant diversity is of special concern to indigenous and local communities, and these communities have a vital role to play in addressing the loss of plant diversity.

If efforts are made at all levels to fully implement this updated Strategy:

- societies around the world will be able to continue to rely upon plants for ecosystem goods and services, including food,

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- medicines, clean water, climate amelioration, rich, productive landscapes, energy sources, and a healthy atmosphere;
- humanity will secure the ability to fully utilize the potential of plants to mitigate and adapt to climate change recognizing the role of plant diversity in maintaining the resilience of ecosystems;
 - the risk of plant extinctions because of human activities will be greatly diminished, and the genetic diversity of plants safeguarded;
 - the rich evolutionary legacy of plant diversity will be used sustainably and benefits arising are shared equitably to solve pressing problems, support livelihoods and improve human well-being;
 - the knowledge, innovations and practices of indigenous and local human communities that depend on plant diversity will be recognized, respected, preserved and maintained; and
 - People everywhere will be aware of the urgency of plant conservation and will understand that plants support their lives and that everyone has a role to play in plant conservation.

7.4 CONSERVATION OF BIODIVERSITY

Biodiversity conservation, the practice of protecting and preserving the wealth and variety of species, habitats, ecosystems, and genetic diversity on the planet, is important for our health, wealth, food, fuel, and services we depend on. It plays an integral role in supporting many sectors of development

Types of Biodiversity

Ex situ conservation

Conserving biodiversity outside the areas where they naturally occur is known as ex situ conservation. Here, animals and plants are reared or cultivated in areas like zoological or botanical parks.

Reintroduction of an animal or plant into the habitat from where it has become extinct is another form of ex situ conservation. For example, the Gangetic gharial has been reintroduced in the rivers of Uttar Pradesh, Madhya Pradesh and Rajasthan where it had become extinct.

Seedbanks, botanical, horticultural and recreational gardens are important centres for ex situ conservation.

In situ conservation

Conserving the animals and plants in their natural habitats is known as in situ conservation. This includes the establishment of

- National parks and sanctuaries
- Biosphere reserves
- Nature reserves
- Reserved and protected forests
- Preservation plots

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- Reserved forests

Agrobiodiversity conservation

After the introduction of cotton, tobacco, sugarcane, sunflower, soyabean and so on, farmers became victims of monocultures in their greed for money. Therefore many of the indigenous varieties of crops were lost. Moreover, the hybrid varieties of fruits and vegetables (e.g. tomatoes), introduced for pulp are more susceptible to disease and pests. Though hybrid varieties are preferred, traditional wild varieties of the seeds should be conserved for future use in the event of an epidemic which would completely wipe out the hybrids.

Botanical gardens, agricultural departments, seed banks etc., alone should not be given the responsibility of agrobiodiversity conservation. Every farmer, gardener and cultivator should be aware of his role in preserving and conserving agrobiodiversity.

7.5 WILDLIFE SANCTUARIES

Any area other than area comprised with any reserve forest or the territorial waters can be notified by the State Government to constitute as a sanctuary if such area is of adequate ecological, faunal, floral, geomorphological, natural, or zoological significance, for the purpose of protecting, propagating or developing wildlife or its environment. Some restricted human activities are allowed inside the Sanctuary area

There are 551 existing wildlife sanctuaries in India covering an area of 119775.80 km², which is 3.64 % of the geographical area of the country (National Wildlife Database, May, 2019).

7.6 NATIONAL PARKS

The List of National Parks in India is as diverse as the terrain and traditions of India. With a count of 103 diverse National parks in India, India has the third highest number of national parks in Asia, after China and Thailand. There is immense variation in the national parks and wildlife sanctuaries in India including Tiger Reserves, Desert Sanctuary, Bird Sanctuary, Marine Parks and even a Floating National park

Take a look at this list of the best national parks and wildlife sanctuaries in India before you decide to go on a wildlife watching spree.

- Jim Corbett National Park.
- Kaziranga National Park.
- Gir Forest National Park.
- Sundarban National Park.
- Satpura National Park.
- Eravikulam National Park.
- Pench National Park.

7.7 BIOSPHERE RESERVES

Biosphere reserves in India. There are 18 Biosphere Reserves in the country. Part of Wayanad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani hills (Tamil Nadu, Kerala and Karnataka). Part of Chamoli, Pithoragarh and Bageshwar districts (Uttarakhand).

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7.8 HOTSPOT BIODIVERSITY AREAS IN INDIA

The British biologist Norman Myers coined the term "biodiversity hotspot" in 1988 as a biogeographic region characterized both by exceptional levels of plant endemism and by serious levels of habitat loss. In 1990 Myers added a further eight hotspots, including four Mediterranean-type ecosystems. **Conservation International (CI)** adopted Myers' hotspots as its institutional blueprint in 1989, and in 1996, the organization made the decision to undertake a reassessment of the hotspots concept. Three years later an extensive global review was undertaken, which introduced quantitative thresholds for the designation of biodiversity hotspots.

According to CI, to qualify as a hotspot a region must meet two strict criteria: it must contain at least 1,500 species of vascular plants (> 0.5% of the world's total) as endemics, and it has to have lost at least 70% of its original habitat. In 1999, CI identified 25 biodiversity hotspots in the book "Hotspots: Earth's biologically Richest and Most Endangered Terrestrial Ecoregions".

Collectively, these areas held as endemics about 44% of the world's plants and 35% of terrestrial vertebrates in an area that formerly covered only 11.8% of the planet's land surface. The habitat extent of this land area had been reduced by 87.8% of its original extent, such that this wealth of biodiversity was restricted to only 1.4% of Earth's land surface. In 2005 CI published an updated titled "Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".

Global Biodiversity Hotspots: World

Africa

A total of 8 Hotspots in African continent hold a diversity of plant and animal life, many of which are found nowhere else on Earth.

Asia-Pacific

Composed of large land areas as well as islands dotting the Pacific seas, these 14 Hotspots represent important biodiversity.

Europe and Central Asia

From the Mediterranean Basin to the Mountains of Central Asia, these four Hotspots are unique in their diversity.

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North and Central America

North and Central America play host to thousands of acres of important habitat.

South America

From Brazil's Cerrado to the Tropical Andes, South America has some of the richest and most diverse life on Earth.

Life on Earth faces a crisis of historical and planetary proportions. Unsustainable consumption in many northern countries and crushing poverty in the tropics are destroying wild nature. Biodiversity is besieged. Extinction is the gravest aspect of the biodiversity crisis: it is irreversible. While extinction is a natural process, human impacts have elevated the rate of extinction by at least a thousand, possibly several thousand, times the natural rate. Mass extinctions of this magnitude have only occurred five times in the history of our planet; the last brought the end of the dinosaur age. In a world where conservation budgets are insufficient given the number of species threatened with extinction, identifying conservation priorities is crucial.

The biodiversity hotspots hold especially high numbers of endemic species, yet their combined area of remaining habitat covers only 2.3% of the Earth's land surface. Each hotspot faces extreme threats and has already lost at least 70% of its original natural vegetation. Over 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to the 35 biodiversity hotspots.

I. Africa

1. Cape Floristic Region
2. Coastal Forests of Eastern Africa
3. Eastern Afromontane
4. Guinean Forests of West Africa
5. Horn of Africa
6. Madagascar and the Indian Ocean Islands
7. Maputaland-Pondoland-Albany
8. Succulent Karoo

II. Asia-Pacific

9. East Melanesian Islands
10. Himalaya
11. Indo-Burma
12. Japan
13. Mountains of Southwest China
14. New Caledonia

III. Europe and Central Asia

23. Caucasus
24. Irano-Anatolian
25. Mediterranean Basin
26. Mountains of Central Asia

IV. North and Central America

27. California Floristic Province
28. Caribbean Islands
29. Madrean Pine-Oak Woodlands
30. Mesoamerica

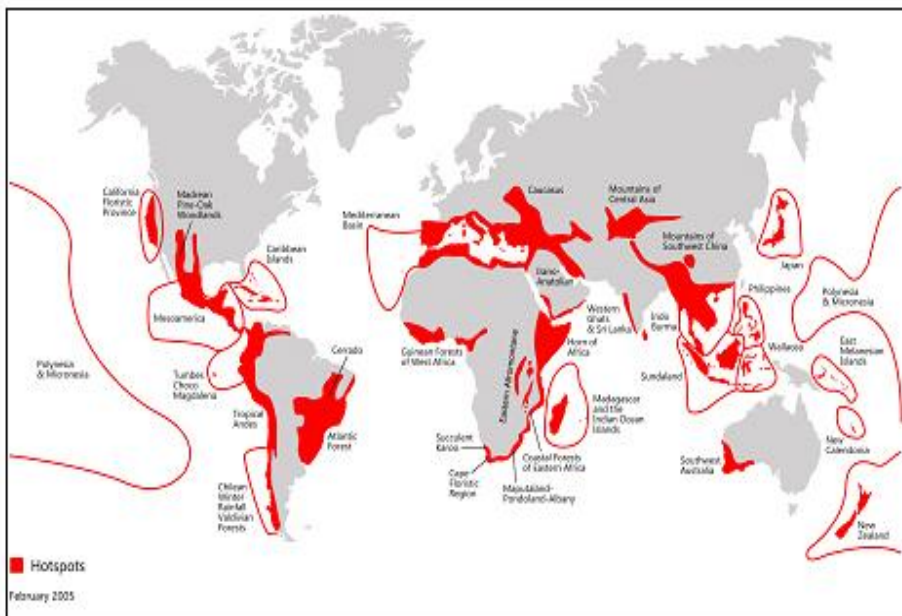
V. South America

31. Atlantic Forest
32. Cerrado
33. Chilean Winter Rainfall-Valdivian Forests
34. Tumbes-Chocó-Magdalen
35. Tropical Andes

15. New Zealand
16. Philippines
17. Polynesia-Micronesia
18. Southwest Australia
19. Forests of Eastern Australia
(new)
20. Sundaland
21. Wallace
22. Western Ghats and Sri Lanka

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CONSERVATION INTERNATIONAL



The map shows 34 biodiversity hotspots which cover 2.3% of the Earth's land surface, yet more than 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to these areas (Conservation International). These are the areas which are suffering biodiversity loss and where attention is needed.

Global Biodiversity Hotspots: Asia-Pacific

1. East Melanesian Islands

Once largely intact, the 1,600 East Melanesian Islands are now a hotspot due, sadly, to accelerating levels of habitat loss.

2. Himalaya

The Himalaya Hotspot is home to the world's highest mountains, including Mt. Everest.

3. Indo-Burma

Encompassing more than 2 million km² of tropical Asia, Indo-Burma is still revealing its biological treasures.

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4. Japan

The islands that make up the Japanese Archipelago stretch from the humid subtropics in the south to the boreal zone in the north, resulting in a wide variety of climates and ecosystems.

5. Mountains of Southwest China

With dramatic variations in climate and topography, the Mountains of Southwest China support a wide array of habitats including the most endemic-rich temperate flora in the world.

6. New Caledonia

An island the size of New Jersey in the South Pacific Ocean, New Caledonia is the home of no less than five endemic plant families.

7. New Zealand

A mountainous archipelago once dominated by temperate rainforests, New Zealand harbors extraordinary levels of endemic species.

8. Philippines

More than 7,100 islands fall within the borders of the Philippines hotspot, identified as one of the world's biologically richest countries.

9. Polynesia-Micronesia

Comprising 4,500 islands stretched across the southern Pacific Ocean, the Polynesia-Micronesia hotspot is the epicenter of the current global extinction crisis.

10. Southwest Australia

The forest, woodlands, shrublands, and heath of Southwest Australia are characterized by high endemism among plants and reptiles.

11. Forests of Eastern Australia

Forests of East Australia Hotspot consists of a discontinuous coastal stretch along the Australian states of Queensland and New South Wales, extending inland and further west, although it includes the New England Tablelands and the Great Dividing Range. This region contains more than 1500 endemic vascular plants.

12. Sundaland

The spectacular flora and fauna of the Sundaland Hotspot are succumbing to the explosive growth of industrial forestry in these islands.

13. Wallacea

The flora and fauna of Wallacea are so varied that every island in this hotspot needs secure protected areas to preserve the region's biodiversity.

14. Western Ghats and Sri Lanka

Faced with tremendous population pressure, the forests of the Western Ghats and Sri Lanka have been dramatically impacted by the demands for timber and agricultural land.

BIODIVERSITY HOTSPOTS IN INDIA

1. **Himalaya:** Includes the entire Indian Himalayan region (and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar)
2. **Indo-Burma:** Includes entire North-eastern India, except Assam and Andaman group of Islands (and Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China)
3. **Sundalands:** Includes Nicobar group of Islands (and Indonesia, Malaysia, Singapore, Brunei, Philippines)
4. **Western Ghats and Sri Lanka:** Includes entire Western Ghats (and Sri Lanka)

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7.9 SUSTAINABLE USE OF PLANT GENETIC RESOURCES

Plants are the primary basis for human sustenance, used directly for food, clothing and shelter, or indirectly in processed form and through animal feeding. Our crop plants have been raised over millennia, through evolutionary forces and human selection, from their wild ancestors. The genetic diversity – the variation in the molecular building blocks that control expression of individual traits – is at the core of a crop's ability to continually undergo these changes. The combination of current and historical genetic diversity underpins our potential to adapt crops to the changing needs of farmers and consumers. FAO strongly supports the sustainable use of plant genetic resources for food and agriculture. In the broadest sense, this encompasses the whole range of actions involved in the conservation, diversification, adaptation, improvement and delivery to farmers through seed systems. Plant breeding acts as bridge between the conservation in genebanks and the seed systems that deliver improved varieties to farmers.

Sustainable use of PGRFA takes into account the wider principles of ecologically, economically and socially sound approaches. These principles address the challenges of meeting basic food needs, generating income for the rural poor, and providing a foundation for protecting the environment. It can involve different technical solutions and actions, such as intensification of production; plant breeding; characterization, evaluation and number of core collections; genetic enhancement and base-broadening; diversification of crop production and broader diversity in crops; development and commercialization of under utilized crops and species; supporting seed production and distribution; and developing new markets for local varieties and "diversity rich" products. Sustainable use of PGRFA also includes the fair and equitable sharing of the benefits arising from the use of PGRFA and agrobiodiversity management

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through appropriate strategies and participatory involvement of stakeholders.

7.10 BIOTECHNOLOGY ASSISTED PLANT CONSERVATION (IN *SITU* AND *EX SITU* CONSERVATION)

Biological diversity provides the variety of life on the Earth and can be defined as the variability among and between the living organisms and species of surrounding ecosystems and ecological complexes of their life support. It has been estimated that one third of the global plant species are threatened in different level according to the International Union of Conservation of Nature (IUCN). The major threat to rapid loss and extinction of genetic diversity due to habitat destruction, pollution, climate change, invasion of exotic species, human population pressure, ever increasing agricultural pressure and practices, life style change etc. are well-known. Biodiversity conservation is a global concern. All member states of the Convention on Biological Diversity (CBD) took measure to preserve both native and agricultural biodiversity. The global concern of biodiversity conservation initiated either by in situ or ex situ methods. In situ methods protect both plants and their natural habitat. On the other hand, ex situ methods involves preservation and maintenance of plant species or plant parts (such as seeds, cuttings, rhizomes, tubers etc.) outside their natural habitat for the purpose of developing seed banks or more preciously gene banks following classical / advanced methods of plant propagation. Classical methods of plant propagations have certain limitations in terms of rapid production of plants or plant propagules and their long term conservation. So, the biotechnological methods such as plant tissue culture, plant cell culture, anther culture, embryo culture etc. are quite applicable and useful techniques for ex situ conservation. On the other hand, the production of superior quality seeds has enhanced by the application of plant biotechnology. So, plant biotechnology offers new means of improving biodiversity conservation rather than threatening biodiversity in various ways.

In situ Conservation

It is one of the methods of the **conservation** of genetic resources in natural populations of plant or animal species. In other words, it is a set of **conservation** techniques involving the designation, management and monitoring of biodiversity in the same area where it is encountered

Ex-situ conservation

Ex-situ conservation involves maintenance and breeding of endangered plants and animals under partially or wholly controlled conditions in specific areas including zoo, gardens, nurseries, etc. That is, the conservation of selected plants and animals in selected areas outside their natural habitat is known as ex-situ conservation. The stresses on living organisms due to competition for food, water, space etc. can be

avoided by ex-situ conservation there by providing conditions necessary for a secure life and breeding. For ex-situ conservations the species to be conserved should be identified followed by adoption of different ex-situ methods such as, long-term captive breeding and propagation for the species which have lost their habitats permanently, short-term propagation and release of the animals in their natural habitat, animal translocation and reintroduction and advanced technology in the service of endangered species. The different advantages of ex-situ conservation are,

It gives longer life time and breeding activity to animals

Genetic techniques can be utilized in the process

Captivity breed species can again be reintroduced in the wild

The ex-situ conservation strategies include botanical gardens, zoological gardens, conservation stands and gene, pollen, seed, seedling, tissue culture and DNA banks. Seed gene banks make the easiest way to store germplasm of wild and cultivated plants at low temperature. While in field gene banks, preservation of genetic resources is being done under normal growing conditions.

Cryopreservation

This type of in vitro conservation is done in liquid nitrogen at a temperature of -196°C . This is particularly useful for conserving vegetatively propagated crops, for example, potato. Cryopreservation is the storage of material at ultralow temperature (-196°C) either by very rapid cooling, as used for storing seeds, or by gradual cooling and simultaneous dehydration, as being done in tissue culture. In cryopreservation, the material can be stored for a considerable long period of time in compact low maintenance refrigeration units.

Botanical Gardens

This is a method of ex-situ conservation of threatened and endangered species in their respective regions. This is maintained by governments at different levels, educational institutions and with the international assistance as well. There are more than 1500 botanic gardens and arboreta in the world containing more than 80,000 species. Many of these botanic gardens now have seed banks, tissue culture facilities and other ex-situ technologies.

Zoological gardens (zoos)

There are more than 800 professionally managed zoos around the world with about 3000 species of mammals, birds, reptiles and amphibians. Many of these zoos have well-developed captive breeding programmes.

The conservation of wild relatives of crop plants, animals or cultures of microorganisms provides breeders and genetic engineers with a ready source of genetic material. Many of the tropical islands are rich in the number of endemic faunal species it possesses, while its record in agro-biodiversity is very impressive as well.

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Check your Progress

1. Name three zones of biosphere reserve
2. Who developed hot spot concept
3. Which state of India has richest flora and fauna
4. Describe the role of the wildlife in modern agriculture
5. Define wildlife. Which animal is used as symbol for WWF?
6. Give an account of biogeographical regions of India
7. What do you understand by management of wildlife
8. Write short notes on hot spots of biodiversity
9. Give an account on Ex situ conservation
10. Write an essay on National parks and Biosphere

7.11 LET US SUM UP

In this block discuss about biodiversity and its conversions. Biodiversity is the variety and variability of life on Earth. Biodiversity is typically a measure of variation at the genetic, species, and ecosystem level. It has been estimated that more than 50 million species of plants, animals and micro-organisms are existing in the world. The role of biodiversity in providing ecosystem services is twofold. Firstly, biodiversity is directly used as a source for food, fibre, fuel and other extractable resources. Biodiversity loss is the extinction of species (plant or animal) worldwide, and also the local reduction or loss of species in a certain habitat. Vegetation types of India due to varied climatic conditions, it has a wide range of natural vegetation. Vegetation of India can be divided into five types – Tropical evergreen forest, Tropical deciduous forest, Thorny bushes, Mountain vegetation and Mangrove forests. Endemism is the ecological state of a species being unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type. Threatened species are divided into these categories: extinct, extinct in the wild, critically endangered, endangered, vulnerable, and near threatened. Conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto. In-situ conservation, the conservation of species in their natural habitats, is considered the most appropriate way of conserving biodiversity. Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats.

7.12 UNIT END EXERCISES

1. Biodiversity concepts

2. Centre's of biodiversity
3. Values and uses of biodiversity and loss of biodiversity
4. Vegetation of India and Tamilnadu
5. Endemism and Red Data Book
6. Biodiversity act of India
7. National parks and Biosphere
8. Biodiversity hotspots

*Biodiversity Act of India 2002
and 2004*

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7.13 ANSWERS TO CHECK YOUR PROGRESS

1. To carry out the complementary activities of biodiversity conservation and sustainable use of natural resources, **biosphere reserves** are traditionally organized into **three** interrelated **zones**, known as the core area, the buffer **zone**, and a transition **zone** or 'area of cooperation.
2. The concept of biodiversity hotspots was developed by the **Norman Myers** in 1988 when he identified that the tropical forest losing its plants species as well as habitat
3. It hosts 4 **biodiversity** hotspots: the Himalayas, the Western Ghats, the Indo-Burma region and the Sundaland (Includes Nicobar group of Islands). These hotspots have numerous endemic species.
4. Wildlife supplies many ecosystem services to the agricultural industry, and farmers can adopt several agricultural practices that enhance wildlife habitat.
5. **WILDLIFE**: Animals living in their natural habitat and not within the possession or control of humans. The inspiration for the WWF logo came from Chi-Chi: a **giant panda** that was living at the London Zoo in 1961, the same year WWF was created.
6. **The bio-geographical province is an ecosystematic or biotic subdivision of realm. India is divided into 25 bio-geographic provinces.** Deccan Plateau is **India's** largest biogeographic region making 42 per cent of the total **geographical area**.
7. **Wildlife management** is a general term for the process of keeping **wild** species at desirable levels as determined by **wildlife managers**. **Wildlife management** can include game keeping, **wildlife** conservation and pest **control**. ... Techniques can include reforestation, pest **control**, irrigation, coppicing and hedge laying.
8. The term biodiversity hotspot specifically refers to 25 biologically rich areas around the world that have lost at least 70 percent of their original habitat.
9. Ex-situ conservation involves maintenance and breeding of endangered plants and animals under partially or wholly

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controlled conditions in specific areas including zoo, gardens, nurseries, etc.

10. A national park is a park in use for conservation purposes. Often it is a reserve of natural, semi-natural, or developed land that a sovereign state declares or owns. **Biosphere** is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, geosphere, hydrosphere, and atmosphere.

7.14 SUGGESTED READING

1. D.L. Hawskworth, 2009, *Methods and Practice in Biodiversity Conservation*, Springer, ISBN: 9789048138487

UNIT – 8 GENERAL AGREEMENT ON TRADE AND TARIFF(GATT)

Structure

- 8.1 Introduction
- 8.2 Objectives
- 8.3 Intellectual Property
- 8.3 Origin and Development of Intellectual property
 - 8.3.1 Paris Convention
 - 8.3.2 Berne Convention
 - 8.3.3 Madrid Agreement
 - 8.3.4 Patent Co-operation Treaty
 - 8.3.5 TRIPS Agreement
 - 8.3.6 World Intellectual Property Organization
- 8.4 Let us sum up
- 8.5 Unit end Exercises
- 8.6 Answer to check your progress
- 8.7 Suggested readings

8.1 INTRODUCTION

Intellectual Property Rights is the recent branch of law and with the growth of ICT in recent days, IPR and library study have gained more importance. Knowing the basics of intellectual property rights before discussing on the implications of intellectual property rights on library services is felt necessary. This chapter discusses on the basics of Intellectual Property Rights.

8.2 OBJECTIVES

- To study about the General Agreement on Trade and Tariff (GATT) and World Trade Organization,
- To know the Establishment and functions of GATT and WTO, Physical and Intellectual Property.

8.3 INTELLECTUAL PROPERTY

Society values the creative fruits of the human mind, believing that they enrich the fabric of life for all of its members. Thus, a system of laws has been developed that confers rights on the creators of these fruits. These rights are collectively known as intellectual property rights, which is commonly abbreviated to 'IPRs' (Edenborough, 1997).

A category of intangible rights protecting commercially valuable products of the human intellect (Garner, 2009). Intellectual property is all about the results of human creativity. Its subject matter is formed by new ideas generated by man. Their application to human needs and desires

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can be of considerable benefit to mankind. New ideas can be embodied in familiar things such as books, music and art, in technical machinery and processes, in designs for household objects and for commercial ventures, and in all other sources of information (Colston, 1999).

TRIPS define intellectual property rights as, the rights given to persons over the creations of their minds. They usually give the creator an exclusive right over the use of his/her creation for a certain period of time (WTO, 2017) The subject matter of intellectual property is very wide and includes literary and artistic works, films, computer programs, inventions, designs and marks used by traders for their goods or services (Bainbridge, 2015)

Intellectual properties are explained by many theories over a time. The first is a natural theory of property which defends the claims that natural facts determine what is property and who owns what. The second approach is in fact a broad class of theories that understand property as a social construction validated in terms of its *instrumental* capacity to produce or secure other ethical goals. The third approach is a labour theory that grounds property claims in productive activity (Das, 2008). Primary understanding of the development of intellectual property rights is very important to have basic knowledge on the evolution of intellectual property at the international level. An international convention on different categories of intellectual property gives the uniform international standards.

8.4 ORIGIN AND DEVELOPMENT OF INTELLECTUAL PROPERTY

8.4.1 Paris Convention

Paris Convention is an International Convention, which provides the common platform for protection of industrial property in various countries of the world. Prior to the existence of any international convention in the field of industrial property, seeking protection for industrial property in various countries was difficult due to diversity of their laws.

Paris convention for the protection of Industrial property was convened in Paris in 1883 and was initially signed by 11 states (WIPO, 2017) Convention was revised at Brussels in 1900, at Washington in 1911, at The Hague in 1925, at London in 1934, at Lisbon in 1958 and at Stockholm in 1967 and was amended in 1979 (WIPO, 2017).

The Paris Convention addresses patents, industrial design rights, trademarks, well known marks, names and unfair competition (Colston, 1999). The Republic of India is a member of Paris Convention since December 7, 1998. At present total 177 member countries are part of the Paris Convention.

8.4.2 Berne Convention

Berne Convention was formulated in the year 1886, for the protection of Literary and Artistic works. “To protect, in as effective and uniform a manner as possible, the rights of the authors in their literary and artistic works” is the aim of the Convention (WIPO, 2017). Berne Convention protects literary works, artistic works, dramatic works, musical works and cinematographic works and it also protects derivative works based on other pre-existing works, such as translation, adaptations, arrangements of music and other alterations of a literary or artistic work. Berne Convention states the duration of the copyright protection as 50 years after the author’s death. The Berne Convention was revised several times to cope up with the technological challenges that is, first revision took place in Berlin in 1908, followed by the revision in Rome in 1928, in Brussels in 1948, in Stockholm in 1967, and in Paris in 1971 (Ahuja, 2015). Basic principles of Berne Convention are, “national treatment”, according to which works originating in one of the member States are to be given the same protection in each of the member States as these grant to works of their own nationals, “automatic protection”, according to which such national treatment is not dependent on any formality that is, protection is granted automatically and is not subject to the formality of registration, deposit or the like, and “independent of protection”, according to which enjoyment and exercise of the rights granted is independent of the existence of protection in the country of origin of the work. It is administered by WIPO.

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8.4.3 Madrid Agreement

Madrid Agreement was framed on April 14, 1891 which deals with International registration of Marks and Protocol related to Madrid Agreement, concluded in 1989. Contracting countries to this Madrid Agreement, secure protection for their marks applicable to goods or services, registered in the country of origin, by filling the said marks at the International Bureau of Intellectual Property. Duration of the protection is valid for 10 years and which can be renewed by paying prescribed fees (Arora, 2016). Currently, total 100 members are under Madrid Agreement covering 116 contracting countries. It is administered by WIPO. 50.

8.4.4 Patent Co-Operation Treaty

The Patent Co-Operation treaty is an International treaty, which assists applicants in seeking patent protection internationally for their inventions. It also helps patent offices with their patent granting decisions, and facilitates public access to a wealth of technical information relating to those inventions. PCT was framed at Washington on June 19, 1970 and the latest amendment to the PCT regulations was done on 1 July, 2017. There are currently 152 contracting countries (Patent Cooperation Treaty, 2017).

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8.4.5 TRIPS Agreement

TRIPS (Trade-Related Aspects of Intellectual Property Rights) Agreement is a multilateral agreement on intellectual property, which came into force on 1 January, 1995. TRIPS Agreement is administered by WTO (World Trade Organization). It is an attempt to narrow the gaps in the way these rights are protected around the world, and to bring them under common international rules (WTO, 2017). The agreement operates on a foundation of two of the existing conventions by embodying the substantive provisions of the Paris and Berne Conventions, as well as adding new provisions (Colston, 1999). The types of intellectual property covered by the TRIPS Agreement are copyright and related rights, trademarks, including service marks, geographical indications, industrial designs, patents, layout-designs of integrated circuits and undisclosed information, including trade secrets. It establishes minimum levels of protection that each government has to give to the intellectual property of fellow WTO members (WTO, 2017).

8.4.6 World Intellectual Property Organization (WIPO)

WIPO is the global forum for intellectual property services, policy, information and cooperation, which was established in the year 1967. Mission of the WIPO is to lead the development of a balanced and effective international intellectual property (IP) system that enables innovation and creativity for the benefit of all. WIPO has 191 member states and headquarters is at Geneva, Switzerland. WIPO administers conventions namely, PCT-The International Patent System, Madrid-The International Trademark System, Hague- The International Design System, Lisbon- The International system of Appellations of Origins , and Budapest-The International Microorganism Deposit System (WIPO, 2017).

Check your progress

1. Write short notes on General Agreement on Trade and Tariff (GATT)
2. Describe the World Trade Organization
3. Give an account on functions of GATT and WTO
4. List out the Physical and Intellectual Property

8.5 LET US SUM UP

- A system of laws has been developed that confers rights on the creators of these fruits. These rights are collectively known as intellectual property rights.
- . “To protect, in as effective and uniform a manner as possible, the rights of the authors in their literary and artistic works” is the aim of the Berne Convention.

- The Patent Co-Operation treaty is an International treaty, which assists applicants in seeking patent protection internationally for their inventions.
- TRIPS (Trade-Related Aspects of Intellectual Property Rights) Agreement is a multilateral agreement on intellectual property, which came into force on 1 January, 1995.
- WIPO is the global forum for intellectual property services, policy, information and cooperation,.Mission of the WIPO is to lead the development of a balanced and effective international intellectual property (IP) system that enables innovation and creativity for the benefit of all.

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8.6 UNIT END EXERCISES

1. What is IPR?
2. What is the purpose of WIPO?
3. What are the various conventions developed for intellectual property?

8.7 ANSWER TO CHECK YOUR PROGRESS

- 1..The General Agreement on Tariffs and Trade (**GATT**) is a legal agreement between many countries, whose overall purpose was to promote international trade by reducing or eliminating trade barriers such as tariffs or quotas.
2. World Trade Organization is an intergovernmental organization that is concerned with the regulation of international trade between nations.
- 3.GATT :Its purpose is the “substantial reduction of tariffs and other trade barriers and the elimination of preferences, on a reciprocal and mutually advantageous basis.
WHO:Its main **function** is to ensure that trade flows as smoothly, predictably and freely as possible
4. **Intellectual property** rights include patents, copyright, industrial design rights, trademarks, plant variety rights, trade dress, geographical indications, and in some jurisdictions trade secrets.

8.8 SUGGESTED READINGS

1. Crowley andA. Meredith,2003, An Introduction to the WTO and GATT, The Columbia University Press.
2. Autar Kkrishen Koul, 2005, The General Agreement on Tariffs and Trade(GATT)/World Trade Organisation(WTO) Law, Economics and Politics, Satyam Book Publishers, ISBN-13: 978-8190288309
3. General Agreement on Tariffs And Trade, 2015, WTO Publications, World Trade Organization, Switzerland, On-line bookshop: <http://www.wto.org/wto/publicat/publicat.htm>.

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UNIT 9 DIFFERENT TYPES OF INTELLECTUAL PROPERTY RIGHTS (IPR)

Structure

- 9.1 Introduction
- 9.2 Objectives
- 9.3 Different types of intellectual property rights (IPR)
- 9.4 Patents,
- 9.5 Trade mark
 - 9.5.1 Industrial Designs
 - 9.5.2 Geographical Indications
- 9.6 Trade secret
- 9.7 Copy right.
 - 9.7.1 Copyright law of India
 - 9.7.2 Term of Copyright
 - 9.7.3 Infringement of Copyright
- 9.8 Let us sum up
- 9.9 Unit end Exercises
- 9.10 Answer to check your progress
- 9.11 Suggested readings

9.1 INTRODUCTION

Plant patent is the patent granted to persons who have created or discovered new and distinct, asexually propagated plants. The components of a plant application are similar to those of a utility application. Patents prevent others from making or selling an invention, but trademarks protect the words, phrases, symbols, logos, or other devices used to identify the source of goods or services from usage by other competitors.

The Difference between Copyright and Trademark. While both offer intellectual property protection, they protect different types of assets. Copyright is geared toward literary and artistic works, such as books and videos. A trademark protects items that help define a company brand, such as its logo

9.2 OBJECTIVES

- To know about Different types of intellectual property rights (IPR)
- To study about Patents, Trade mark, Trade secret and Copy right.

9.3 DIFFERENT TYPES OF IPR

According to WIPO, Intellectual property is divided into two categories that is, Industrial Property and Copyright. Industrial property includes patents for inventions, trademarks, industrial designs and

geographical indications. Copyright covers literary works (such as novels, poems and plays), films, music, artistic works (e.g., drawings, paintings, photographs and sculptures) and architectural design. Rights related to copyright include those of performing artists in their performances, producers of phonograms in their performances, producers of phonogram their recordings, and broadcasters in their radio and television programs (WIPO, 2017).

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9.4 PATENTS

Patents are granted in respect of inventions, i.e. technological improvements, great and small, which contain at least some scintilla of inventiveness over what is previously known (Cornish, et.al., 2010). As per WIPO, A Patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. According to Halsbury's Laws of England, the word patent is used denoting a monopoly right in respect of an invention.

Patent is a monopoly right conferred by Patent Office on an inventor to exploit his invention subject to the provisions of Patents Act for a limited period of time (Ahuja, 2015). Patents are territorial rights and the exclusive rights are only applicable in the country or region in which a patent has been filed and granted, in accordance with the law of that country or region (Patents-WIPO, 2017).

Invention means a new product or process involving an inventive step and capable of industrial application (The Patents Act of 1970). Novelty, inventive step, lack of obviousness and sufficiency of description are the essential ingredients for patents (Narayana, 2013). The term of validity for every patent under Patent (Amendment) Act, 2002, shall be twenty years from the date of filing of the application for the patent. The term of patent in case of International applications filed under the Patent Cooperation Treaty designating India, shall be twenty years from the international filing date accorded under the Patent Cooperation Treaty. In India patents are governed by Patents Act, 1970 and the act is amended by the Patent (Amendment) Act, 2002.

9.5 TRADEMARKS

According to WIPO, a trademark is a sign capable of distinguishing the goods or services of one enterprise from those of other enterprises. A product can be copied by a competitor and can become outdated by the introduction of new products, but a trade mark is unique. A successful trade mark is timeless and the most important source of market power and enables its owner to diversify in products and geographical markets (Bansal, 2014).

Internationally trademark is observed under Madrid protocol. Duration of International registration of trademark is valid for ten years and it can be renewed for ten years from the expiry of preceding period. Protection of trademarks in India is governed by The Trademarks Acts,

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1999, which is amended in the year 2010 i.e., Trademarks (Amendment) Act, 2010. Registration in India is also valid for ten years and can be renewed time to time in accordance with the provisions of the Act. Trademark is a mark which includes a device, brand, heading, label, ticket, name, signature, word, letter, numeral, shape of goods, packaging or combination of colours or any combination thereof (The Trade Marks Act of 1999). Trade mark performs four functions, namely identifying the product and its origin, it guarantees its unchanged quality, advertising the product and creating the image of the product. The function of Service mark in relation to services is same to that of a trade mark in relation to goods (Narayana, 2013).

9.5.1 Industrial Designs

According to WIPO, an industrial design may consist of three dimensional features, such as the shape of an article, or two dimensional features, such as patterns, lines or colour. In a legal sense, an industrial design constitutes the ornamental or aesthetic aspect of an article. In India industrial designs are governed under Designs Act, 2000. "Design" means only the features of shape, configuration, pattern, ornament or composition of lines or colour applied to any article whether in two dimensional or three dimensional or in both forms, by any industrial process or means, whether manual, mechanical or chemical, separate or combined, which in the finished article appeal to and are judged solely by the eye; but does not include any mode or principle of construction or anything which is in substance a mere mechanical device (The Designs Act of 2000). Design is prohibited from registration when it is not new or original, or has been disclosed to the public anywhere in India or in any other country by publication in tangible form or by use or in any other way prior to the filing date, or where applicable, the priority date of the application for registration, or which is not significantly distinguishable from known designs or combination of known designs or comprises or contains scandalous or obscene matter shall not be registered (The Designs Act of 2000). Registered proprietor for a registered design will have a copyright in the design during ten years from the date of registration (The Designs Act of 2000). Copyright in the design can be extended for the period of five years, if, before the expiration of the ten years, application for the extension of the period of copyright is made to the Controller in the prescribed manner (The Designs Act of 2000).

9.5.2 Geographical Indications

"Geographical indication", in relation to goods, means an indication which identifies such goods as agricultural goods, natural goods or manufactured goods as originating, or manufactured in the territory of a country, or a region or locality in that territory, where a given quality, reputation or other characteristic of such goods is essentially attributable to its geographical origin and in case where such goods are manufactured goods one of the activities of either the

production or of processing or preparation of the goods concerned takes place in such territory, region or locality (The Geographical Indications of Goods (Registration and Protection) Act).

WIPO expresses, geographical indication (GI) as a sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin. Geographical indications are typically used for agricultural products, foodstuffs, wine and spirit drinks, handicrafts, and industrial products (Geographical Indications WIPO, 2017).

Geographical indications in India are administered under The Geographical Indications of Goods (Registration and Protection) Act, 1999. Registration of GI shall be valid for the duration of ten years and may be renewed time to time in accordance with the provisions of the section. The basic three functions of geographical indications are, firstly, they identify goods as originating in particular territory, or a region or locality in that territory; secondly, they suggest the consumers that the goods come from an area where a given quality, reputation or other characteristic of the goods is essentially attributable to their geographic origin; and thirdly, they promote the goods of producers of a particular area (Ahuja, 2015).

9.6 TRADE SECRET

A **trade secret** is a type of intellectual property in the form of a formula, practice, process, design, instrument, pattern, commercial method, or compilation of information that is not generally known or reasonably ascertainable by others, and by which a person or company can obtain an economic advantage over competitors. In some jurisdictions, such secrets are referred to as *confidential information*. A trade secret is information that

- i. is not generally known to the public;
- ii. confers economic benefit on its holder *because* the information is not publicly known; and
- iii. the holder makes efforts to maintain its secrecy.

In international law, these three factors define a trade secret under article 39 of the Agreement on Trade-Related Aspects of Intellectual Property Rights, commonly referred to as the TRIPS Agreement

9.7 COPYRIGHT

Copyright was recognized only after invention of printing in the 15th century, which enabled the reproduction of books in large numbers. Before that, creative writers, musicians, artists wrote, composed or made their works for fame and recognition rather than to earn a living and question of copyright never arose because copying was a laborious and expensive process (Narayana, 2013).

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WIPO defines, Copyright (or author's right) is a legal term used to describe the rights that creators have over their literary and artistic works. Works commonly protected by copyright throughout the world include:

- literary works such as novels, poems, plays, reference works, newspaper articles;
- computer programs, databases;
- films, musical compositions, and choreography;
- artistic works such as paintings, drawings, photographs, and sculpture;
- architecture; and advertisements, maps, and technical drawings (WIPO, 2017)

9.7.1 Copyright law of India

Copyright is a right given by the law to creators of literary, dramatic, musical and artistic works and producers of cinematograph films and sound recordings. In fact, it is a bundle of rights including, *inter alia*, rights of reproduction, communication to the public, adaptation and translation of the work (Handbook of Copyright Law).

"Copyright" means to do or authorise the doing of any of the following acts in respect of a work, such as literary, dramatic or musical work, not being a computer programme, computer programme, an artistic work, cinematograph film, sound recording (Indian Copyright Act of 1957). Copyright in India is governed by the Copyright Act, 1957, which was came into effect from January 1958. Further, the act was revised and amended time to time in the years, 1983, 1984, 1991, 1994, 1999, and 2012.

9.7.2 Term of Copyright

Term of copyright subsist in published literary, dramatic, musical and artistic works (other than photograph) published within the lifetime of the author until sixty years from the beginning of the calendar year next following the year in which the author dies and in case of joint authorship, be constructed as a reference to the author who dies last (Indian Copyright Act of 1957). Term of copyright in case of a literary, dramatic, musical or artistic work (other than photograph), which is published anonymously or pseudonymously, copyright will exists sixty years from the beginning of the calendar year (Indian Copyright Act of 1957).

9.7.3 Infringement of Copyright

Infringement of intellectual property happens when someone attempts to exploit the rights conferred on the respective owners under different forms of IP without the assent of the owners or persons authorized by them. Copyright is one of the form of intellectual property (Gopalakrishnan, 2009). According to the section 51, Indian Copyright Act, 1957, copyright in a work shall be deemed to be infringed-

a) When any person, without a license granted by the owner of the copyright or the Registrar of Copyrights under this Act or in

contravention of the conditions of a license so granted or of any condition imposed by a competent authority under this Act-

- i) Does anything, the exclusive right to do which is by this Act conferred upon the owner of the copyright or
- ii) Permits for profit any place to be used for the communication of the work to the public where such communication constitutes an infringement of the copyright in the work, unless he was not aware and had no reasonable ground for believing that such communication to the public would be an infringement of copyright, or

b) When any person-

- i) Makes for sale or hire, or sells or lets for hire, or by way of trade displays or offers for sale or hire, or
- ii) Distributes either for the purpose of trade or to such an extent as to affect prejudicially the owner of the copyright, or
- iii) By way of trade exhibits in public, or
- iv) Imports into India, any infringing copies of the work (Indian Copyright Act of 1957).

Provisions related to Protection of technological measures, under section 65A (1) of The Copyright (Amendment) Act, 2012, states, any person who circumvents an effective technological measure applied for the purpose of protecting any of the rights conferred by this Act, with the intention of infringing such rights, shall be punishable with imprisonment which may extend to two years and shall also be liable to fine.

Fair Use

An exception to infringements is fair use. Some unauthorized uses of copyright work for certain specific reasons are allowed by law and they are not considered as an infringement of that work and such unauthorized use is termed as “fair use” or “fair dealing” (Ahuja, 2015) Fair use is the right to use a copyrighted work under certain conditions without permission of the copyright owner (Copyright and Fair use: A Guide for the Harvard Community). Fair use provisions relating to free uses in the act is to strike a balance between the interests of the copyright owner and the interests of the society at large (Ahuja, 2015). Fair use exceptions of India, U.S.A. and U. K., related to library are discussed.

Fair Use and India

In India, provisions regarding Fair use or fair dealing are dealt in the section 52, under Indian Copyright Act, 1957 which are related to library services. According to Section 52 (1)(a) fair dealing with a literary, dramatic, musical or artistic work (not being a computer programme) for the purpose of private use, including research and criticism or review, whether of that work or of any other work is a fair use.

Reproduction of literary, dramatic, musical or artistic work by a teacher or a pupil in the course of instruction is a fair use (Indian

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Copyright Act of 1957). Reproduction in a newspaper, magazine or other periodical of an article on current economic, political, social or religious topics, unless the author of such article has expressly reserved to himself the right of such reproduction (Indian Copyright Act of 1957). Non-commercial public library can make not more than three copies of a book (including a pamphlet, sheet of music, map, chart or plan) by or under the direction of the person in charge of a Non-commercial public library for the use of the library if such book is not available for sale in India (Indian Copyright Act of 1957). According to statutes of law, non-commercial public library cannot make copies of the book, if they are available for sale in India.

Reproduction for the purpose of research or private study or with a view to publication, of an unpublished literary, dramatic or musical work kept in a library, museum or other institution to which the public has access provided author or authors known to the library or institution and provision is made after sixty years of death of author or death of author who dies at last in case of joint authors (Indian Copyright Act of 1957). Storing of a work in any medium by electronic means by non-commercial public library, for preservation if the library already possesses a non-digital copy of the work (The Copyright (Amendment) Act, 2012).

Fair Use and U.S.A.

Doctrine of fair use is often called the safety valve of copyright, for the users of copyright information (Schlosser, 2006). According to United States Copyright law, fair use is judged upon satisfaction of four factors, which include 1) The purpose and character of use, including whether such use is of a commercial nature or is for non-profit educational purposes; 2) the nature of the copyrighted work; 3) the amount of substantiality of the portion used in relation to the copyrighted work as a whole; and 4) the effect of the use upon the potential market for or value of the copyrighted work (17 U.S. Code. § 107).

The United States Copyright Act is particularly solicitous of educational and academic uses in many circumstances which benefits users of copyrighted material in and around the academic or research library which is included in the specific exceptions contained in the sections 108, 110, and 121 of the Copyright Act and special protections granted by Section 504(c)(2) (Association of Research Libraries, 2015). Section 108 of the U.S. Copyright Act (17 U.S. Code. § 108), provides the statutory framework regarding limitations on exclusive rights: reproduction by libraries and archives. Section 108 (a) states that, library can reproduce no more than one copy of a work, to distribute under the condition that, reproduction or distribution should not be directly or indirectly for commercial advantage. Collection of the library are open to public and to all researchers affiliated or not affiliated to institution.

Library when makes such copy should provide copyright notice, even if it is not provided in the original copy (17 U.S. Code. § 108).

Section 108(b) states reproduction and distribution of unpublished work up to three copies is allowed for the purpose of preservation and security (17 U.S. Code. § 108). Further, it say the copy reproduced is currently the collection of the library and if the copy is reproduced in digital format, it cannot be made available to outside public in that format.

Section 108(c) gives the right to reproduce or duplicate the published work in three copies if the copy or phono records is damaged, deteriorating, lost/stolen or current format in which it is stored has become obsolete (17 U.S. Code. § 108). Condition mentioned is that, copy can be reproduced or duplicated only if it is not available after reasonable efforts or replacement cannot happen at a fair price.

There are rights to make a copy of no more than one article or other contribution to a copyrighted collection or periodical issue or to a copy or phono record of a small part of any other copyrighted work, when there is a request from user or from other library or archives (17 U.S. Code. § 108) under the section 108(d). When a copy of the copyrighted work after reasonable investigation, cannot be obtained at a fair price, there are rights under section 108(e) for reproduction and distribution to the entire work, or to a substantial part of it, made from the collection of a library, where the user makes his or her request or from that of another library (17 U.S. Code. § 108).

Further it says, the copy becomes the property of the user, and the library has no notice that, the copy would be used for any purpose other than private study, scholarship, or research; and the precaution notice saying copyright in accordance with requirements that the Register of Copyrights shall prescribe by regulation, should be prominently displayed, at the place of orders accepted and also in its order form (17 U.S. Code. § 108).

Fair Use and U.K.

Fair use is commonly referred as a fair dealing in UK copyright law. Fair dealing in Copyrights, Designs, and Patents (CDPA) Act, 1988, covers a making of temporary copies; research and private study (non-commercial); copies for text and data analysis for non-commercial research; criticism, review, quotation and new reporting; caricature, parody, or pastiche; and incidental inclusion of copyright material, under general provisions (Copyrights, Designs, and Patents Act of 1988).

Provisions of fair dealing for libraries and archives is governed by section 40A to section 44 A of the CDPA Act, 1988. Lending of the book, audio-book, or e-book which is lawfully acquired by the library and lending in compliance with licensing or purchasing term, is fair dealing (Copyrights, Designs, and Patents Act of 1988). Communicating work to the public or making it available to the public by means of

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terminal on its premises by the institutions (a library, an archive, a museum and an educational establishment) with the condition that the copy or work is made available or communicated, for the purpose of research or private study by the individual members or public, which is made available in compliance with the licensing terms to which the work is subject (Copyrights, Designs, and Patents Act of 1988).

Librarian can make a single copy of a whole or part of the published work to supply it to another library, without infringing copyright of the work, if the request from other library is for, not for profit and at the time of making a copy library does not find out the person who has a copyright in the work. Making a copy of an article in a periodical to supply it to another library against the request do not need authorised person's approval (Copyrights, Designs, and Patents Act of 1988). And where library charges for supplying a copy under section 41, the sum charged must be calculated by reference to the costs attributable to the production of the copy. Making a copy of an work which is a part of institution's collection by a librarian, archivist or curator of library in order to preserve or replace that item or where the particular work of another library has been lost, damaged or destroyed, in order to replace the item in the collection of that library, archive or museum, provided the item is included in the part of the collection which is kept wholly or mainly for the purposes of the reference on the institution's premises; where it is part of collection which is not accessible to the public and which is not for profit; available on loan only to other libraries, archives or museums (Copyrights, Designs, and Patents Act of 1988).

A librarian is permitted to make and supply single copy of one article of a periodical or reasonable proportion of any other work against the declaration in writing from the person who requests for a copy and the declaration should include name of the person and details of materials requested, statement that expresses, he should not have supplied previously the material requested by that person by any library, declaration that, the material requested is purely for research or private study for non-commercial purpose (Copyrights, Designs, and Patents Act of 1988).

A librarian can make a single copy of the whole or part of a unpublished work without infringing copyright in the work provided request from person, declares it is for non-commercial purpose or for private study and the same copy has not been supplied to the person but at the time of making a copy the librarian or archivist is to be aware of the fact that, the work had been published or communicated to the public before the date it was deposited in the library or archive or the copyright owner has prohibited the copying of the work (Copyrights, Designs, and Patents Act of 1988).

Check your Progress

Note: a. Write your answer in the space given below

b. Compare your answer with those given at the end of the unit.

1. What you know about biosafety? Write in detail the biosafety guidelines and regulation for release of genetically engineered goods
2. Define Patents
3. Write short notes on Trademark
4. Write an essay on patenting the biological materials
5. What is the intellectual property right? Discuss in detail the different forms of its protection
6. Write short notes on Copyrights

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9.8 LET US SUM UP

Conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto. In-situ conservation, the conservation of species in their natural habitats, is considered the most appropriate way of conserving biodiversity. Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats.

9.9 UNIT END EXERCISES

1. Intellectual property rights (IPR)
2. Discuss Infringement of Copyright
3. What is patent?
4. Elaborate trade secrets.

9.10.ANSWER TO CHECK YOUR PROGRESS

1. Biosafety is the prevention of large-scale loss of biological integrity, focusing both on ecology and human health. Guidelines
 - a.Recombinant DNA guidelines, 1990
 - b. Guidelines for research in transgenic crops, 1998The two main agencies identified for implementation of the rules are the Ministry of Environment, Forests and Climate Change and the Department of Biotechnology, Government of India. The rules have also defined competent authorities and the composition of such authorities for handling of various aspects of the rules.
2. Patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem.
3. According to WIPO, a trademark is a sign capable of distinguishing the goods or services of one enterprise from those of other enterprises.
4. Biological **patent** is a patent on an invention in the field

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of biology that by law allows the patent holder to exclude others from making, using, selling, or importing the protected invention for a limited period of time.

5. Intellectual property is a category of property that includes intangible creations of the human intellect. There are many types of intellectual property, and some countries recognize more than others. The most well-known types are copyrights, patents, trademarks, and trade secrets.
6. Copyright (or author's right) is a legal term used to describe the rights that creators have over their literary and artistic works.

9.11 SUGGESTED READINGS

1. Biber – Klemm and T. Cottier, 2006, Rights of plants genetics resources and traditional knowledge: Basic issues and Perspectives, Cabi Publication, ISBN: 9780851990330

UNIT 10 PLANT BIOTECHNOLOGICAL

Structure

- 10.1 Introduction
- 10.2 Objectives
- 10.3 Topic of concerns on website of ICGEB
- 10.4 Plant biotechnological examples of patents
- 10.5 Intellectual Property Right and Protection
- 10.6 Forms of Protection
 - 10.6.1 Patents
 - 10.6.2 Copyrights
 - 10.6.3 Trade Secrets
 - 10.6.4 Trademarks
- 10.7 The World Intellectual Property Organization
- 10.8 Let us sum up
- 10.9 Unit end Exercises
- 10.10 Answer to check your progress
- 10.11 Suggested readings

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10.1 INTRODUCTION

Due to growing concerns arising from GMOS throughout the world the UNIDO/WHO/FAO UNEP has built up an Informal Working Group on Biosafety. In 1991, this group prepared the "Voluntary Code of Conduct for the Release of Organisms into the Environment". The ICGEB has also played an important role in issue related to biosafety and the environmentally sustainable use of biotechnology. The ICGEB organizes annual workshops on biosafety and on risk assessment for the releases of GMOs. It collaborates with the management of UNIDO's BINAS (Biosafety Information Network and Advisory Service), aimed at the monitoring the global development in regulatory issues in biotechnology. Since September 1998, the ICGEB has provided an on-line bibliographic data base. This database which is accessible through the website of ICGEB also provides informations on the biosafety of its Members States. The ICGEB is also assisting to its Member States in developing the national biosafety framework. Since February 1999, it has also adopted a legally binding biosafety protocols by the signatory countries (ICGEB, Activity Report, 1998).

10.2 OBJECTIVES

1. To study the Plant biotechnological examples of patents, trademark, trade secret and copyright. Plant breeder's rights.

10.3 TOPIC OF CONCERNS ON WEBSITE OF ICGEB

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The main "topic of concern" related to the environmental release of GMOS are given below:

(i) Risks for human health

- ❖ toxicity and food quality/safety
- ❖ allergies
- ❖ pathogens' drug resistance i.e. antibiotic resistance

(ii) Risks for the environment

- ❖ Persistence of gene or transgene or transgene products
- ❖ Resistance of target organisms or susceptibility of non-target organisms
- ❖ increased use of chemicals in agriculture
- ❖ transgene instability
- ❖ unpredictable gene expression

(iii) Risks for agriculture

- ❖ weeds or superweeds
- ❖ alteration of nutritional value
- ❖ reduction of cultivars and loss of biodiversity

❖ Due to growing concerns arising from GMOS throughout the world the UNIDO/WHO/FAO UNEP has built up an Informal Working Group on Biosafety. In 1991, this group prepared the "Voluntary Code of Conduct for the Release of Organisms into the Environment". The ICGEB has also played an important role in issue related to biosafety and the environmentally sustainable use of biotechnology. The ICGEB organizes annual workshops on biosafety and on risk assessment for the releases of GMOs. It collaborates with the management of UNIDO's BINAS (Biosafety Information Network and Advisory Service), aimed at the monitoring the global development in regulatory issues in biotechnology. Since September 1998, the ICGEB has provided an on-line bibliographic data base. This database which is accessible through the website of ICGEB also provides informations on the biosafety of its Members States. The ICGEB is also assisting to its Member States in developing the national biosafety framework. Since February 1999, it has also adopted a legally binding biosafety protocols by the signatory countries (ICGEB, Activity Report, 1998).

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10.4 PLANT BIOTECHNOLOGICAL EXAMPLES OF PATENTS

Due to growing concerns arising from GMOS throughout the world the UNIDO/WHO/FAO UNEP has built up an Informal Working Group on Biosafety. In 1991, this group prepared the "Voluntary Code of Conduct for the Release of Organisms into the Environment". The ICGEB has also played an important role in issue related to biosafety and the environmentally sustainable use of biotechnology. The ICGEB organizes annual workshops on biosafety and on risk assessment for the releases of GMOs. It collaborates with the management of UNIDO's BINAS (Biosafety Information Network and Advisory Service), aimed at the monitoring the global development in regulatory issues in biotechnology, Since September 1998, the ICGEB has provided an on-line bibliographic data base. This database which is accessible through the website of ICGEB also provides informations on the biosafety of its Members States. The ICGEB is also assisting to its Member States in developing the national biosafety framework. Since February 1999, it has also adopted a legally binding biosafety protocols by the signatory countries (ICGEB, Activity Report, 1998).

10.5 INTELLECTUAL PROPERTY RIGHT (IPR) AND PROTECTION

Generally, the physical objects such as household goods or land are the properties of a person. Similarly, a country has its own property. The ownership and rights on the property of a person is protected by certain laws operating in the country. This type of physical property is tangible. On the other hand, the transformed microorganisms, plants and animal and technologies for the production of commercial products are exclusively the property of the intellectuals. The discoverer has the full rights on his property. It should not be neglected by the others without legal permission. The right of intellectuals must be protected and it does by certain laws framed by a country. However, it is important to distinguish between the physical property and intellectual property. For example, seed of a plant is tangible asset; it can be sold in market and money can be made from it. But the intellectual property is intangible

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asset. Legal rights or patents provides an inventor only a temporary monopoly on the use of an invention, in return for disclosing the knowledge to the others in a specification that is intended to be both comprehensive to, and experimentally reproducible by a person skilled in the art. Others in society may use the knowledge o develop further inventions and innovations (Bull et al 1993). The laws are formulated time to time at national and international levels. The USA has declared for adopting a strong and no byplantbreeders rights" (PBRs). The Biosafety of occasional onfered rt, export and mese guidelines The PBRs are available in developed countries but not in India. The principle of PBRs recognizes the pact that farmers and rural communities have contributed a lot exchange and kowledge of genetio species utilization of genetic diversity. The IPR and IPP granted by the government to plant breeders to exclude others from producing or commercializg materials of a specific plant variety for about 15-20 years. But this variety should never existing before. Biotechnology has played a significant role in providing processing, designing and production valuable commercial products utilizable in many are at instihutional the creation, conservation, DBT which DEW environment and el and open nducts, health as the country (eg eac)Tochnology transfer in biotechnology agrieul mum amount of technical and legal capability which the developing countries lack onsindustries present. Therefore, manpower developing countries must come out together and reach to an understanding to help in various mutual programmes

10.6 FORMS OF PROTECTION

The IPR is protected by different ways: patents, copyrights, trade secrets and trade marks

10.6.1 Patents

Patent is a special right to the inventor that has been granted by the Government through legislation for trading new articles. A patent is a personal property which can be lised or sold by the person organisation just like any other property. For example, Alexander Graham Bell obtained patent for his telephone this gave him the power to preve engine from making or using or selling a telephone elsewhere. In some icles beneficial monopoly rights were granted only to the inventiors so that they for 17 years. In India for the society. In the USA the maximum limit of t not the 'product patent, and the Indian Patent Act (1970) allows the 'proces date of grant, and 7 years from the date of f patent is for y tion between five and seven years is applicable for he Bt gene to to evaluate ins of yeast maximum duration filing the patent application. The least patents. The conditions of patents are permission IMTECH given in the preceding section. The patents in terms give the right to exclude the others from making, using or terms give the in production east and E.

The patents selling his invention as disclosed in 'claims' of the patent. Obviously, it is difficult to keep secret the certain inventions such as the fermentation process. Therefore, guidance should be obtained from a qualified patent attorney.

A patent consists of three parts; the grant, specifications and claims. The grant is filed at the patent office which is not published. It is a signed document which is actually the agreement, the specification and claims are published as that grants patent right to the inventorial a minimum charge from the patent office. The single document which is in which the subject matter of invention is described how the specification is put out. The claim section specifically defines the scope of the invention to be protected by the patent to which the others may not practice.

The most important issue of discussion is the operation example, Food and Drug Administration of the US has regulatory purview on patented pharmaceuticals before permitting for clinical use. Similarly, the Environment Protection Agency of the USA working under the Federal Insecticide, Fungicide and Rodenticide Act permits the release of genetically engineered microbial pesticides. The local 'nuisance' has formulated minimize the excessive use of genetically engineered inventions. In Environmental the recombinant DNA safety guidelines Protection Act (1986). The 'genetic engineering approval committee (GEAC) of the Ministry of Environment and Forest has the powers to allow large scale use of GEMs at commercial level and open field trials of transgenic materials (see preceding section).

10.6.2 Copyrights

The copyright protection is only a form of expression of ideas. One of the best example of copyrights is the books. The authors, editors, publishers or both publisher and author/editor have copyrights. The materials of the book cannot be reprinted and without written permission from copyright holders. However, it should trade secrets provide protection of only basic knowhow, whereas copyrights protect materials viz., materials in printed, video-recorded or taped forms. Biotechnological materials subject to copyright include database of DNA sequence or any published forms, photomicrographs, clear that patents express etc.

10.6.3 Trade Secrets

The private proprietary information that benefits the called trade secret. It may be of any type, from process to product yield. The most owners popular example is Coca Cola that has covered its best kept secrets of its formula under this law. It is surprising to know that India does not have trade secrets. Therefore, it allows any company to register and protect the details of formulae. Usually, a patent runs out for 10-20 years, but under the law of trade secrets India, the limit of trade secrets is at least five years and two years in the USA. If the trade secrets become public before the granted period, the intellectual is paid compensation

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and unauthorised users are punished by the Court. The trade secrets in the area of biotechnology may comprise of hybridization conditions, cell lines, processing. Designing, consumer's list, etc

10.6.4 Trademarks

A trade mark is an identification symbol which is used in the course of trade to enable the public to distinguish on trader's goods from the similar goods of the other traders. The public makes use of these trade works in order to choose whose goods they will have to buy. If they are satisfied with the purchase, they can simply repeat their order by using the trade mark, for example KODAK for photography goods, IBM for computers, Zodiac for readymade cloths, etc. The advantages of patents and other forms of IPR are: (i) encouraging and safeguarding intellectual and artistic creations, (ii) disseminating new ideas and technologies quickly and widely, (iii) promoting the investment, (iv) providing consumers with the result of creation and invention, (v) providing increased opportunities for the distribution of the above effects across the countries in a manner proportionate to national levels of economic and industrial development (OECD, Paris, 1989).

10.7 THE WORLD INTELLECTUAL PROPERTY ORGANISATION (WIPO):

The WIPO is one of the necialized agencies of the United Nations. It has provided that the intellectual property shall include rights relating to the following (0 389 and scientific works, performance of artists, phonograms, broadcast marks and commercial me scientific discoveries; trade marke service and all other rights resulting from intellectual activity in the area literary or artistic fields (i) The intellectual property is protected by and governed by appropriate national legislation The national legislation specifically describes the inventions which are the subject matter of protection and those which are excluded from a protection, for example, methods of treatment of humans or therapy and invention whose use would be contrary to law or invention which are injurious Indian legislation 22.2.3. General Agreement of Tariffs and Trade (GATT) and Trade Related IPR signs; protection against unfair competition industrial, scientific public health are excluded from patentability in the (TRIPS). The GATT was framed in 1948 by developed countries to settle the disputes among the countries regarding share of world trade. It is decided by tariffs rates and quantitative developed countries. In 1988, the US C ted a law the Omnibus Trade and Competitiveness Act (OTCA).

As a result of which the USA became powerful to investigate the laws related to trade and check them investigated country does not change its law within the desired period, the US takes action against that country, In 1992, the US gave warning to India to change some of its

laws of IPR patents and copyrights. India had certain inhibitions to sign on GATT draft. Therefore, there was much debate throughout the country on this issue and bad intension of the US. Professionals, politicians and scientists argued that the total package of TRIPS must guarantee for economic and technological subjugation of the country not beneficial to its interest. After warning if the then Director General of GATT, A. Dunkel came to India for discussion on this issue. Certain provisions were suggested to include in GATT draft that India will not give any kind of subsidies for the production of oilseeds and pulses as the international price is more than that in India. India assured to change its patent laws by 2003, In the changed patent it will intro product patent and enhance patent duration here are several gh patent bolders anisations also, and open the agriculture to patent that have rejected this draft of suggestion and opposed the decision taken by the government.

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Patenting of Biological Materials. As discussed earlier that different countries have different patent laws which are changed with Chakrabarty (an India born A is superbug could not be patented because the existing US Pseudomonas which eats upon laws before 1980 did not p issued to genetically engineered mouse 'oncomouse (containing In 1988 in the US ch is again a liveform. Dr. Chakrabarty filed a case in the US Supreme t of time for example Dr. Anand Mohan tist) created a superbug by using bacterium, t to patent the liveforms. Lateron the patent laws were amended man cancer In 1990 the US government allowed him to treat oil spills by using Preudomonas ndwn based superbug.

Conditions for Patenting: There has been a debate on the patentable articles and conditions related with them.I red article is the product of nature Yes, the process or t like that every discovery can be granted patents. Discovery cannot be patented because techniques used to discover the nature's product may be granted patents. Therefore, patent laws differentiate between discovery and invention, and allow patenting of inventions but not discoveries The European Patent Office (EPO) has given suggestions that the process developed to isolatethe products from nature is patentable. If the product is new and does not have previously existing nition (eg microbial metabolites, andibiotics, alcobols, organie acids, vitamins, enr etc), it is patantable. Therefore, the specific conditions for patent application should (0 the ducible (will give qualify for patent Le (0 the invention must have novelty and utility for product must be inventive Le skill has been applied to it, (i) it must similar result after repetition) and disclosed, (v) scope of protection should be in proportion to the invention, and (v) it must be patentable Before filing the patent application the inventor must deposit a sample of officially approved material declaring that it is free from dispute of novel legally free. Moreover, the application may be withdrawn before the grant of patent.

Patentlng of Liveforms: As discussed carlier, EPO has suggested to patent the genetically engineered liveforms. Also oncomouse patent

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claims was rejected but on appeal the previous decision, tPA, etc have been introduced and can be used by others when becomes examples of which initially the overruled. Similarly, genetically coll in which human genes for insulin, icide- and bollworm-resistant cotton, one of the engineered have been patented and insect-resistant tobacco have been granted pater Europe, etc) have modified the patent laws stating that the transgenic plants and animals can be protected through patent claims.

Significance of Patents in India. The Indian Patents Act (1970) emphasises that any the USA. Likewise, transgenic several countries (such as Japan, USA, patentable commodity must possess novelty. The Chen balwa', 'rice idli', 'rice pongal' and tent office believes that South Indian delicacies like 'medu vadai", rava uppama even green pea's 'masala' are the novel process preparations to the Dasaprakas Hotel Chain. The Mumbai patent office hasgranted a process patent to Dilip Shantaram Dahanunkar for the preparation of 'tomato rasam and custard chill ja spread used as pizza topping. The same person has been given a patent for an improved process for preparation of vitaminised sweet and sour lemon pickle rice and a process for manufacturing 1973. Patents were granted for these popular banana sauce. In 1995, the USA had granted a patent to the Medical Centre, University of Mississippi (USA) for use of turmeric (Aald) powder as a wound healing agent. Council of Scientific and Industrial Research, New Delhi (India) objected this patent. Consequently, the patent grant was revoked following serious objection in an order passed on August 13, 1997, In 1997, the EPO has given a favourable interim judgment on the challenge of a European patent on the fungicidal effect of neem oil owned by W. Grace & Co. The challenge to neem patent was done by Dr. Vandans Shiva Ms Magda Alvoet (M.P. of the European Parliament) and the other NGOS of neem campaign Recenty, the US government has patented the Indian 'Basmati' rice as 'Ricitech. The Government of India is trying to revoke the patent claim of the US and restore its patentability just like turmeric.

Check your Progress

Note: a. Write your answer in the space given below

b. Compare your answer with those given at the end of the unit.

1. Write short notes on following i) Trade secret ii) GATT iii) TRIPs
2. Write essay on operation of biosafety guideline in India
3. Define biosafety
4. Define GMMs
5. Explain the WIPO
6. Write an essay on Trade secret and Trade mark

10.8 LET US SUM UP

In this unit, you have learnt about the intellectual property rights includes principles, types, general agreement on trade and tariff and world trade organization and also deals with plant biotechnological examples of patents, trade mark, trade secret and copy right and plant breeder's rights etc. Genetically modified plants are flavr savr tomato, basmati rice, neem and turmeric also discussed.

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10.9 UNIT END EXERCISES

1. Why is patenting important?
2. How is trade mark commercially important?
3. Intellectual property protection is needed. Explain why?
- 4.

10.10 ANSWER TO CHECK YOUR PROGRESS

1

i. Trade **secret** is a type of intellectual property in the form of a formula, practice, process, design, instrument, pattern, commercial method, or compilation of information that is not generally known or reasonably ascertainable by others, and by which a person or company can obtain an economic advantage over

ii)The General Agreement on Tariffs and Trade (**GATT**) is a legal agreement between many countries, whose overall purpose was to promote international trade by reducing or eliminating trade barriers such as tariffs or quotas.

iii.The Agreement on Trade-Related Aspects of Intellectual Property Rights (**TRIPS**) is an international legal agreement between all the member nations of the World Trade Organization (WTO).

2. **India's Biosafety and Recombinant DNA Guidelines** (1990) falls under the Environment (Protection) Act of 1986. In 1994, after **India** signed the Biodiversity Convention, the DBT revised its earlier **guidelines** to accommodate the safe handling of GMOs in research, application and technology transfer.

3.Biosafety is the prevention of large-scale loss of biological integrity, focusing both on ecology and human health.

4. Genetically modified foods, also known as genetically engineered foods, or bioengineered foods are foods produced from organisms that have had changes introduced into their DNA using the methods of genetic engineering.

5.The World Intellectual Property Organization is one of the 15 specialized agencies of the United Nations. WIPO was created in 1967 "to encourage creative activity, to promote the protection of intellectual property throughout the world".

6. A **trademark** protection may extend perpetually. A **trademark** (also written trade mark or trade-mark) is a type of intellectual property consisting of a recognizable sign, design, or expression which identifies

products or services of a particular source from those of others **Trade Secrets: Trade secrets** protect valuable **secret** information like ideas that must be kept confidential.

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10.11 SUGGESTED READINGS

1. Biber – Klemm and T. Cottier, 2006, Rights of plants genetics resources and traditional knowledge: Basic issues and Perspectives, Cabi Publication, ISBN: 9780851990330

UNIT 11 FLAVR SAVR™ TOMATO AS A MODEL CASE FOR GM FOOD

*Flavr savr™ tomato as a model
case for gm food*

Structure

- 11.1 Introduction
- 11.2 Objectives
- 11.3 Flavr Savr™ tomato as a model case for GM food,
- 11.4 Case studies on patents (Basmati rice)
 - 11.4.1 Basmati Patent
 - 11.4.2 Identification of Basmati Rice
- 11.5 Case studies on patents (Neem)
- 11.6 Case studies on patents (Turmeric)
- 11.7 General guidelines for research in transgenic plants.
 - 11.7.1 Introduction
 - 11.7.2 Coverage off the revised guidelines
 - 11.7.3 Statutory bodies dealing with the recombinant DNA work
- 11.8 Categories of Genetic Engineering Experiments on plants and their notifications
- 11.9 Let us sum up
- 11.10 Unit end Exercises
- 11.11 Answer to check your progress
- 11.12 Suggested readings

NOTES

11.1 INTRODUCTION

Flavr Savr. Flavr Savr (also known as CGN-89564-2; pronounced "flavor saver"), a genetically modified tomato, was the first commercially grown genetically engineered food to be granted a license for human consumption. Flavr Savr tomatoes, one of its gene, responsible for ripening is modified using genetic engineering technique, so that the shelf life of tomato is increased, or in other words, process of tomato ripening is slowed by genetic modification by reducing the expression of already existing gene.

Basmati rice, sought-after for its fragrant taste, was developed by Indian farmers over hundreds of years, but the Texan company RiceTec obtained a patent for a cross-breed with American long-grain rice. RiceTec was granted the patent on the basis of aroma, elongation of the grain on cooking and chalkiness. India has won a 10-year-long battle at the European Patent Office (EPO) against a patent granted on an anti-fungal product, derived from neem. EPO initially granted the patent to the US Department of Agriculture and multinational WR Grace in 1995. The turmeric patent was granted in 1995 to two researchers, Soman K. Das and Harihar Kohli of the University of Mississippi Medical Center.

11.2 OBJECTIVES

- To study about Flavr Savr™ tomato as a model case for GM food,
- To Case studies on patents (Basmati rice, Neem and Turmeric,), General guidelines for research in transgenic plants.

11.3 FLAVR SAVR™ TOMATO AS A MODEL CASE FOR GM FOOD

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Flavr Savr (also known as CGN-89564-2; pronounced "flavor saver"), a genetically modified tomato, was the first commercially grown genetically engineered food to be granted a license for human consumption

In 1994, Calgene, a California company, brought the first genetically engineered crop to market, the Flavr Savr tomato. The company's researchers were able to inhibit a gene that produces a protein that makes a tomato get squishy. This tomato caused an enormous media stir.

However, after extensive safety research by Calgene and dialogue with the FDA, the FDA found Calgene's tomato to be safe and approved the FLAVR SAVR tomato on May 17, 1994. Unfortunately the production of Flavr Savr tomato ceased in 1997 because escalating costs prevented the company from becoming profitable

The FLAVR SAVR™ tomato was developed through the use of antisense RNA to regulate the expression of the enzyme polygalacturonase (PG) in ripening tomato fruit.

A genetically modified tomato, or transgenic tomato, is a tomato that has had its genes modified, using genetic engineering. The first trial genetically modified food was a tomato engineered to have a longer shelf life (the Flavr Savr), but never made it to market.

The FLAVR SAVR tomato was the first genetically engineered crop product to be commercialized. The research and marketing efforts that produced the FLAVR SAVR tomato resulted in scientific success, a temporary sales success, and then commercial demise



Flavr savr™ tomato as a model case for gm food

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11.4 CASE STUDIES ON PATENTS (BASMATI RICE)

11.4.1 Basmati patent

The US patent office granted a patent to 'RiceTec' for a strain of Basmati rice, an aromatic rice grown in India and Pakistan for centuries. Rice is the staple food of people in most parts of Asia, especially India and Pakistan. For centuries, the farmers in this region developed, nurtured and conserved over a hundred thousand distinct varieties of rice to suit different tastes and needs. In 1997, in its patent application Ricetec also acknowledged that "good quality Basmati rice traditionally come from northern India and Pakistan...Indeed in some countries the term can be applied to only the Basmati rice grown in India and Pakistan." However, the company then went on to claim that it had invented certain "novel" Basmati lines and grains "which make possible the production of high quality, higher yielding Basmati rice worldwide." The Indian Government had pursued to appeal only 3 claims out of 20 claims made in the original patent application of RiceTec Inc. What were being challenged were only claims regarding certain characteristics of basmati (specifically starch index, aroma, and grain dimensions). It is to be noted that WTO Agreement does not require countries to provide Patent protection to plant varieties. It only requires countries to legislate so that plant varieties are protected in some manner (not necessarily through patents). However, US being a strong proponent of Patent protection of plant varieties allowed the patent application. Three strains development by RiceTec are allowed patent protection and they are eligible to label its strain as "Superior Basmati Rice". Therefore, in Basmati case, RiceTec altered the strain through crossing with the

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Western strain of grain and successfully claimed it as their invention and the case is an example of problems illustrated in TRIPS with regards to patenting biotechnological processes.

11.4.2 Identification of Basmati Rice

The Case Issue In the late 1997, when an American company RiceTec Inc. was granted a patent by the US patent office to call the aromatic rice grown outside India "Basmati", India objected to it. India has been one of the major exporters of Basmati to several countries and such a grant by the US patent office was likely to affect its trade. Since Basmati rice is traditionally grown in India and Pakistan, it was opined that granting patent to RiceTec violated the Geographical Indications Act under the TRIPS agreement. A geographical indication (sometimes abbreviated to GI) is a name or sign used on certain products which corresponds to a specific geographical location or origin (e.g.. a town, region, or country). The use of a GI may act as a certification that the product possesses certain qualities, or enjoys a certain reputation, due to its geographical origin. RiceTec's usage of the name Basmati for rice which was derived from Indian rice but not grown in India, and hence not of the same quality as Basmati, would have lead to the violation of the concept of GI and would have been a deception to the consumers.

RiceTec Company Details ∪ Owned by Prince Hans-Adam of Liechtenstein. ∪ 120 company employees. ∪ Annual sales 10 million US Dollars. ∪ Rice developed by RiceTec are: Bas 867, RT 1117, RT 112. Company's Words "We are absolutely confident in our patent and viability and legality. There is no basis for challenging the patent". RiceTec Inc. Patent Claims RiceTec put 20 claims about their product from which few ones are: ∪ semi-dwarf in stature ∪ substantially photoperiod insensitive ∪ high yield ∪ Having characteristics similar or superior to those of good quality basmati rice ∪ The invention provides a method for breeding these novel lines ∪ Starch index (SI) of a rice grain can predict the grain's cooking and starch properties Claiming that "Aroma" has been developed by RiceTech Inc. is misleading ∪ RiceTech Inc. claimed that it took them 10 years to develop the Aroma in their rice line ∪ Branding a Basmati lookalike as Basmati ∪ They used inbreeding of ordinary american rice with sub continental Basmati rice and patented this hybrid as Basmati RiceTec Inc. Patent Claims, Patent Advantage to RiceTech RiceTec able to not only call its aromatic rice Basmati within the US, but also label it Basmati for its exports. Captures the whole US trade market. Exclusive use of the term "basmati". Monopoly on breeding 22 farmer-bred Pakistani basmati varieties with any other varieties in the Western Hemisphere. Proprietary rights on the seeds and grains from any crosses.



Flavr savr™ tomato as a model case for gm food

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11.5 CASE STUDIES ON PATENTS (NEEM)

Neem Patent

The patent for Neem was first filed by W.R. Grace and the Department of Agriculture, USA in European Patent Office. The said patent is a method of controlling fungi on plants comprising of contacting the fungi with a Neem oil formulation. A legal opposition has been filed by India against the grant of the patent. The legal opposition to this patent was lodged by the New Delhi-based Research Foundation for Science, Technology and Ecology (RFSTE), in co-operation with the International Federation of Organic Agriculture Movements (IFOAM) and Magda Aelvoet, former green Member of the European Parliament (MEP). A tree legendary to India, from its roots to its spreading crown, the Neem tree contains a number of potent compounds, notably a chemical found in its seeds named azadirachtin. It is used as an astringent in so many fields. The barks, leaves, flowers, seeds of neem tree are used to treat a variety of diseases ranging from leprosy to diabetes, skin disorders and ulcers. Neem twigs are used as antiseptic tooth brushes since time immemorial. The opponents' submitted evidence of ancient Indian ayurvedic texts that have described the hydrophobic extracts of neem seeds were known and used for centuries in India, both in curing dermatological diseases in humans and in protecting agricultural plants from fungal infections. The EPO identified the lack of novelty, inventive step and possibly form a relevant prior art and revoked the patent. Apart from this, several US patents were recently taken out on Neem-based emulsions and solutions.

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Fig.11.2 Neem Tree with Twig

11.6 CASE STUDIES ON PATENTS (TURMERIC PATENT)

Turmeric is a tropical herb grown in east India. Turmeric powder is widely used in India as a medicine, a food ingredient and a dye to name a few of its uses³. For instance, it is used as a blood purifier, in treating the common cold, and as an anti-parasitic for many skin infections. It is also used as an essential ingredient in cooking many Indian dishes. In 1995, the United States awarded patent on turmeric to University of Mississippi medical center for wound healing property. The claimed subject matter was the use of "turmeric powder and its administration", both oral as well as topical, for wound healing. An exclusive right has been granted to sell and distribute. The Indian Council for Scientific and Industrial Research (CSIR) had objected to the patent granted and provided documented evidences of the prior art to USPTO. Though it was a well known fact that the use of turmeric was known in every household since ages in India, it was a herculean task to find published information on the use of turmeric powder through oral as well as topical route for wound healing. Due to extensive researches, 32 references were located in different languages namely Sanskrit, Urdu and Hindi. Therefore, the USPTO revoked the patent, stating that the claims made in the patent were obvious and anticipated, and agreeing that the use of turmeric was an old art of healing wounds. Therefore, the TK that belonged to India was safeguarded in Turmeric case.



Turmeric rhizome with powder

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**11.7 GENERAL GUIDELINES FOR RESEARCH IN
TRANSGENIC PLANTS**

11.7.1. Introduction

The revised present document is meant for the researchers in the country who are involved in recombinant DNA research on plants. Earlier the Department of Biotechnology in January 1990 issued a compendium of guidelines under the title “Recombinant DNA Safety Guidelines”. A revision was made in 1994 under the title “Revised Guidelines for Safety in Biotechnology”. The current guidelines have been developed in the light of enormous progress that has been made in recombinant DNA research and its widespread use in developing improved microbial strains, cell lines and transgenic plants for commercial exploitation.

11.7.2. Coverage of the revised guidelines

The current guidelines cover areas of recombinant DNA research on plants including the development of transgenic plants and their growth in soil for molecular and field evaluation. The guidelines also deal with import and shipment of genetically modified plants for research use only.

11.7.3. Statutory bodies dealing with the recombinant DNA work

In accordance with the Notification No. GSIR 1037 (E) dated 5th December, 1989 of the Ministry of Environment & Forests which empowers the Review Committee on Genetic Manipulation (RCGM) to bring out manuals of guidelines specifying procedure for regulatory process with respect to activities involving genetically engineered organisms in research use and applications including industry with a view to ensuring environmental safety, the present changes in the procedures are being made. These changes are made reiterating the powers conferred on the RCGM to lay down procedures restricting or prohibiting production, sale, importation and use of genetically engineered organisms or cells as are mentioned in the attached schedule of the above mentioned notifications.

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A. IBSC (Institutional Biosafety Committee)

i. The IBSC is the nodal point for interaction within an Institute/ University/commercial organisation involved in r-DNA research for the implementation of the recombinant DNA guidelines. As such, in the first instance, it is necessary that the organisations intending to carry out research activities involving genetic manipulation of microorganisms, plants or animals should constitute their IBSC in accordance with the procedures in vogue and as informed to the public through the above notification. All recombinant research carried out by the organisation should have a designated Principal Investigator (P.I.). It would be the duty of the P.I. to apprise its IBSC about the nature of the experiments being carried out. Depending upon the category of the experiments as narrated on in the present guidelines the P.I. Can inform the IBSC about the recombinant experiments, seek permission of IBSC before starting the experiments or seek the permission of the RCGM through its IBSC in cases where the risks involved in the experiments are considered to be of higher magnitude having the potential of polluting/ending the environment, the biosphere, the eco system, the animals and the human beings.

The Department of Biotechnology in January 1990 enumerates the duties of the IBSC in pages 15-16 of the original “Recombinant DNA Safety Guidelines” prepared.

B. RCGM (Review Committee on Genetic Manipulation)

- i. The RCGM is functioning in the Department of Biotechnology to monitor the safety-related aspects of ongoing research projects involving genetically engineered organisms.
- ii. The RCGM shall include representatives of a) Department of Biotechnology; b) Indian Council of Medical Research; c) Indian Council of Agricultural Research; d) Council of Scientific and Industrial Research; and e) others experts in their individual capacity. RCGM may appoint subgroups to monitor specific projects.
- iii. The RCGM would review all the reports of all approved on-going research projects involving high-risk category and controlled field experiments.
- iv. The RCGM or its constituted subgroups shall visit the site of experimental facilities periodically, where projects with biohazard potential are being pursued and also at a time prior to the commencement of the activity to ensure that adequate safety measures have been taken as per the guidelines.
- v. The RCGM would issue the clearance for import/export of etiologic agents and vectors, transgenic germplasms including transformed calli, seeds and plant parts for research use only.
- vi. The RCGM shall meet at least twice in a year.

- vii. For research in recombinant DNA work-involving risks categorised as category-III and above in this revised document the permission of the RCGM through the Department of Biotechnology must be obtained by the P.I. Before conducting the research work.
- viii. RCGM can authorise applicants (P.I.s) to conduct limited field trails in multi locations in the country. The design of the trial experiments is either provided by the RCGM or it may approve the protocol designed by the P.I. The protocol will seek answers related to animal and human health. Data should also be generated on economic advantage of the transgenics over the existing varieties.
- ix. RCGM can, if required, direct the applicants to generate toxicity, allergenicity and any other relevant data on transgenic materials in appropriate systems. RCGM may design or approve a protocol for conducting experiments to seek answers to the above.
- x. The RCGM can put such conditions as would be required to generate long term environmental safety data from the applicants seeking release of transgenic plants into the open environment, and who have complied with initial safety evaluation.
- xi. RCGM can approve applications for generating research information on transgenic plants. Such information may be generated in contained green house as well as in very small plots, as research needs to be conducted in such environment for seeking answers to specific environmental safety issues emanating from the use of transgenic plants. The small experimental trials should be limited to a total area of 20 acres in multi-locations in one crop season. In one location where the experiment is conducted with transgenic plants, the land used should not be more than one acre. Any experiment beyond the above limits in one crop seasons would require the approval of the Genetical Engineering Approval Committee (GEAC).
- xii.

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11.8 CATEGORIES OF GENETIC ENGINEERING EXPERIMENTS ON PLANTS AND THEIR NOTIFICATIONS

A. Category I

This category includes routine cloning of defined genes, defined non-coding stretches of DNA and open reading frames in defined genes in *E. coli* or other bacterial and fungal hosts which are GENERALLY CONSIDERED AS SAFE (GRAS) to human, animals and plants. A list

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of such microorganisms will be prepared by the RCGM and shall be made available to the P.I. on request.

This category involves experiments in the lab in contained environment and includes the following:

- i. Routine cloning of defined DNA fragments of microbial, animal and plant origin in GRAS organisms.
- ii. Transfer of defined cloned genes into *Agrobacterium*;
- iii. Use of defined reporter genes to study transient expression in plant cells to study genetic transformation conditions;
- iv. Molecular analysis of transgenic plants grown in-vitro.

Categories I experiment need only intimation to the IBSC in the prescribed proforma (available with the RCGM secretariat).

B. Category II

This category includes lab and green house/net house experiments in contained environment where defined DNA fragments non-pathogenic to human and animals are used for genetic transformation of plants, both model species and crop species and the plants are grown in the green house/net house for molecular and phenotypic evaluation.

This category includes the experiments described below:

1. Transgenics with constitutive, tissue specific and chimeric promoters used for experimenting expression of defined DNA fragments.
2. Marker genes extensively used in genetic transformation of plants in lab and green house/net house experiments.
3. Lab and green house/net house experiments with plants with herbicide resistance conferring genes;
4. Lab and green house/net house experiments with plants using heterologous genes which confer resistance to biotic and abiotic stresses (i.e. genes like chalcone synthase, heat shock proteins, chitinase, protease inhibitors etc);
5. Lab and green house/net house experiments with genes from plants, animals and microbial sources that would confer resistance to plant pathogens.
6. Lab and green house/net house experiments with transgenics with genes for the production of antibodies.
7. Green house/net house experiments with transgenics with transposable elements for gene tagging in crop species.

Permission for performing Category II experiments will be provided by IBSC. The decision of the IBSC would be intimated to the RCGM before execution of the experiments and RCGM would put this information on record.

C. Category III & Above

This category pertains to high risk experiments where the escape of transgenic traits into the open environment could cause significant alterations in the biosphere, the ecosystem, the plants and animals by dispersing new genetic traits, the effects of which can not be judged precisely. All experiments conducted in green house and open field conditions not belonging to the above Category II types, would fall under Category III risks. Such experiments could be conducted only after clearance from RCGM and notified by the Department of Biotechnology:

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11.3.5. CONTAINMENTS

Different levels of containment are prescribed for the three different categories of rDNA experiments.

1. Category I experiment should be performed using routine good laboratory practices (See Appendix I for details)
2. For Category II experiments dealing with evaluation of transgenics in green house/net house, the designs for the contained facility shall be as described in Appendix II. The transgenic experiments of Category II risks will have to be carried out in green house/net house, the specification of which is significantly stringent to ensure arrest of transgenes within the contained facility.
3. For Category III experiments in green house/net house, the later needs to be designed as indicated broadly in Appendix II. The specifications of the green house/net house have been designed to ensure near complete isolation of the facilities from the open environment; care has also been taken to prevent the entry of insects into the green house/net house facility.

For limited field experiments in the open environment, the RCGM would provide for and/or would approve the design of the experimental field plots.

Monitoring and evaluation mechanisms for green house/ net house experiments and limited field trials in the open environment

The RCGM can bring out manuals of Guidelines specifying procedures for regulatory process with respect to activities involving genetically engineered organisms in research and applications to ensure environmental safety. To monitor, over a period of time, the impact of transgenic plants on the environment, a special Monitoring cum Evaluation Committee of the following constitution will be set up by the RCGM. The Committee shall have the following constitution.

- a) Chairman of the Committee: Secretary, DBT & Secretary, DARE shall jointly discuss and elect a leader of the committee.
- b) Eminent Plant Biotechnologists: To be nominated by RCGM, 3-4 Nos.
- c) Seed Technologies: To be nominated by ICAR, 2-3 Nos.

- d) Plant Breeders: To be nominated by ICAR, upto 2 Nos.
- e) Plant Ecologists/Environmentalists: To be nominated by RCGM, upto 2 Nos.
- f) Nominee of NBPGR: To be nominated by ICAR.
- g) Nominee of MOE&F: To be nominated by the Chairman, GEAC
- h) Member-Secretary: Member-Secretary, RCGM

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This committee will undertake field visits at the experimental site/s. The committee shall be guided by the RCGM on the design of field experiments and on the preparation of formats for collecting scientific information on plants in green house/net conditions as well as in limited field trials. Based on the on-the-spot situation the committee can suggest remedial measures to adjust the original trial design and assist the RCGM in collecting, consolidating and analysing the field data for evaluating the environmental risks emanating from the transgenic plants. This committee shall also collect or cause to collect the information on the comparative agronomic advantages of the transgenic plants. From time to time, the committee shall advise the RCGM on the risks and benefits from the use of the transgenic plants put into evaluation. Trials will be done for at least one year with minimum four replications and ten locations in the agroecological zone for which the material is intended. The biological advantage of transgenic will have to be clearly enumerated by the applicant, the Institution, the University or the Industry. The latter would recommend those transgenics, which would be found to be environmentally safe and economically viable by the RCGM, to the Genetic Engineering Approval Committee for consideration for release into the environment.

Biosafety aspects of the transgenic plants

Experiments are designed to systematically identify the hazards, to access to risks and to take step to manage the risks by applying logically valid strategies, to systematically identify the hazards and to assess the risks; the information on the following aspects would be required to be generated.

- I. Characteristics of the donor organisms providing the target nucleic acids. These may include the following:
 - 1. Name of the donor organism with its identification characteristics with relevant reference to published information if any.
 - 2. Pathogenically and toxicity characteristics to plants and animals.
 - 3. Allergenicity characteristics to human alongwith of the allergenic substances, wherever possible.
 - 4. The geographical origin of the organisms, its distribution pattern and survival mechanisms.

5. The method of transfer of its genetic materials to other organisms.
- II. Characteristics of the vectors used: These may include the following:
1. The origin, identity and habitat of the vectors used.
 2. The sequence, frequency of mobilisation, specificity and marker genes if any, present in the vectors.
 3. The abilities of the vectors to get established in other hosts; the hosts are also to be specified.
- III. Characteristics of the transgenic inserts: These may include the following:
1. The specific functions coded by the inserted nucleic stretches including the marker gene inserts.
 2. The expression of the nucleic acid products and their activities/properties.
 3. The toxicity of the expression products on the host plant, if any.
 4. The toxicity and allergenicity of the nucleic acid products to human and animals.
- IV. Characteristics of the transgenic plants: These may include the following:
1. Methods of detection of the transgenic plant in the environment.
 2. Methods of detection and characterization of the escaped transgenic traits in the environment.
 3. Toxicity and pathogenicity of the transgenic plants and their fruits to other plants in the ecosystem and the environment.
 4. Possibility of and the extent of transgenic pollen escape and pollen transfer to wild near relatives, and the consequences to the environment.
 5. Pathogenicity, toxicity and allergenicity of the transgenic plants and their fruits to human and animals.

Information on many of the above questions may already be available. Many questions may however be required to be investigated and answers found out, for which appropriate new experiments would have to be designed to gather data. For generating toxicity and allergenicity data, standard protocols devised by international agencies could be used. The Indian national toxicological laboratory like the Industrial Toxicology Research Centre, Lucknow could be consulted to generate appropriate protocol for these purposes.

For minimizing the risk arising from the limited release of transgenic plants, the following may be taken into consideration:

1. Special separation for isolation, for preventing reproduction/fertilisation and seed setting.

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2. Biological prevention of flowering by making use of sterility properties etc.
3. Human intervention for the removal of reproductive structures of flowers.
4. Controlling the reproductive structures of transgenic plants like the seeds and the plant propagules from unaccounted spread.
5. Controlling and destroying volunteer plants from the experimental field.
6. To take into account the proximity to human activity in case the transgenic plants have allergenic properties to human and animals.
7. Appropriate training of field personnel responsible for handling the transgenic plants.
8. Plans for handling unexpected events.
9. Documentation of previous published information, if any, including any documented evidence of effects of release to ecosystem.

Thorough comparison with national checks for productivity and susceptibility/resistance to biotic and abiotic stresses will have to be made.

All the information as above are to be documented in the form of a document which would be called the registration document.

Import and shipment of transgenic germplasm for research purposes:

Clearance for import of transgenic material, for research purposes would be provided by the RCGM. The RCGM will issue an import certificate after looking into the documents related to the safety of the material and the national need. The RCGM will take into consideration the facilities available with the importer for in-soil tests on the transgenic material. The importer of a transgenic material may import the material accompanied by an appropriate phyto-sanitary certificate issued by the authority of the country of export, and such import may be routed through the Director, NBPGR on the basis of the import permit issued by the DBT, based on the recommendations of the RCGM. The import certificate would be cancelled if NBPGR would not provide the phyto-sanitary certificate. NBPGR will provide information on the time that is required for phyto-sanitary evaluation. These evaluations will be done in a time-bound manner in presence of the agents of the institutes or the commercial organisations that are importing the material, if they so desire. Parts of the seed material will be kept at NBPGR in double lock system in the presence of the importer. This lot of seed will act as a source material in case of any legal dispute.

APPENDIX – I

Flavr savr™ tomato as a model case for gm food

GOOD LABORATORY PRACTICES

1. Use a pipettor for all the solution transfers. No mouth pipetting.
2. Plug pipettes with cotton.
3. Do not blow infectious material out of pipettes.
4. Do not prepare mixtures of infectious material by bubbling expiratory air through the liquid with a pipette.
5. Before and after infecting an animal, swab the site of injection with a disinfectant.
6. Sterilise discarded pipettes and syringes in pan where they were first placed after use.
7. Before centrifuging, inspect tubes for cracks. Inspect the inside of the Turin cup for rough walls caused by erosion or adhering matter. Carefully remove all bits of glass from the rubber cushion.
8. Use of centrifuge tinnion cups with screw caps or equivalent.
9. Avoid decanting centrifuge tubes; if you must do so, wipe off the outer rim with a disinfectant. Avoid filling the tube to the point that the rim ever becomes wet with culture.
10. Sterilise all contaminated material before discarding.
11. Periodically, clean out deep-freeze and dry-ice chests in which cultures are stored to remove broken ampules or tubes. Use rubber gloves and respiratory protection during the cleaning.
12. Avoid smoking, eating and drinking in the laboratory.
13. Do not reuse plasticware that has been used for PCR, recombinant DNA work and plant transformation work.
14. Sterilise all the plasticware before discarding it.
15. Burn all the transgenic material in an incinerator after observations have been taken.

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APPENDIX – II

Model plant for the construction of a green house/ net house for experiments using transgenic plants:

Frame Structure:

The structure should be made from galvanised mild steel designed to with stand wind loading of not less than 100 km/hour. The method of affixing the polythene film cover to the frame should be strong enough to with stand similar wind velocities. The base may be constructed with bricks and cement or with any durable structure up to a height of 1.5 to 2

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feet from the ground level so as to isolate the land inside the framed structure from the outside land.

Optimum size of unit:

The recommended minimum size of the unit would be 1000 to 1500 cubic meters. In dimensions each such unit may be 30 meters long 13 meters wide and having and under the gutter height of about 3 to 4.5 meters from the base. The plan view as well as the side view of a multi span unit with double door entry recommended for an optimum size unit is enclosed along with this appendix-II. It is recommended that all the green house structures should have double door entry as indicated in the enclosed drawings, and the span of the area for the double door entry can be kept as 5 to 6 meters in length and about 3 meters in width along with height maintained commensurate with the main structure of the unit. The main entrance may be optionally be provided with an air curtain. The outer door shall be only one panel of flush door opening inside the buffer area and the inside doors may be more than one (two sliding doors have been shown in the drawing). In case sliding doors are not installed, the inside doors should be of one panel each, opening inside the buffer area only. The entry wall can be utilised for housing the suction fans as shown in the drawing while the opposite wall can be mounted with evaporation pads (shown in the drawing). The optimum sized unit recommended above would provide a growing area of about 350 sq. meters, allowing 10% for path ways. This unit have a Volume of about 1100 - 1200 cubic meters. Such a unit would be able to maintain a stable temperature, the desired humidity with adequate and ample air circulation.

Plastic film covering:

It is recommended that the area covering the frame should be of 200 micron (800 gauge) thickness, UV stabilised polymer film. Such materials are expected to have a life span of 4 to years. All coverings should be double film covering on all surfaces to give double UV filtration and a more stable temperature control. The roof covers are likely to be inflated by the action of blower fans, thus maintaining a cavity throughout the unit. In addition to it's suggested that an internal separation wall can be constructed to bifurcate the spans if there are more than one, which can be done by fixing the plastic films to the securing rails. Within the whole unit facilities can thus be provided for separate crop studies.

Fan, Pad system and Filter screens:

An evaporative cooling system will be required to enable the maintenance of stable temperature gradient from the site of evaporating pad to the suction end. The surface are of the cooling unit will depend upon the overall all size of the structure. If the unit exceeds 30 meters in length then the temperature variation through out the length of unit may be such than an even temperature may not be maintainable even with the introduction of turbo circulation fans. The dimensions of the evaporation pad required to obtain a temperature 15 degree centigrade below ambient

for a give volume of green house can be calculated from the following approximate equation.

Pad area (P) = Length X Width X Height, the whole divided by 94.85

Where, P is in sq. Meter area.

As an example it is stated that a unit having the dimensions of 30 meters X 13 meters X 3 meters requires a pad area of not less than 12.35 Sq. meters. As most pad units are constructed to order, it is expected that it would not be difficult to have the pad areas of correct size.

All external surfaces of the pad should have filter screens of at least a 40 X 30 mesh net covering made from durable plastic material.

The fans required for a unit of above dimensions, to be housed at the other end of the unit should be about 61 centimeters (24 inch) in diameter with low noise and high C.u. ft./min (CFM) air circulation capacity, with four numbers to be installed per unit. It is recommended that motors with 1.5 H.P. with three phase may be installed which is slightly over designed but which is expected to have more life span and there fore substantial saving on replacements. Compromises can be made by installing 1 H.P. three phase motors, but this may need more maintenance. The fan units should have 40 X 40 mesh durable plastic screen fitted to the out side of the external surface. Each motor unit can be connected to one semi automatic temperature controlled which should shut down the fan as and when the temperature drops below the required levels. Such designs are available in the market.

Blower fans are required to be fitted on the each roof section which will inflate the top roof sheet. These fans must also to be fitted with 40 X 40 mesh durable plastic screen on the induction side to prevent any pollen evacuation. As these fans are expected to be constantly in operation it is recommended that these should be fitted with bearings and not with bust type.

It is essential to have circulation fans within the green house to ensure that a uniform temperature is maintained though out the growing area. The number and the positioning will however depend upon the external conditions and therefore may vary from place to place. The manufacturer may be consulted for selecting the correct number.

Irrigation:

Full over head irrigation systems are available and can be installed. In smaller houses it would be advisable to carryout the watering manually as regulation of humidity is difficult to maintain through over head irrigation system because any extra watering will increase the humidity level. In line feeding units can be installed to take care of the nutrient requirements of the plants. A water tank needed to supply water to the pads and irrigation may be installed slightly below the ground level to avoid direct influence by sun or solar heat. The water will therefore remain cool.

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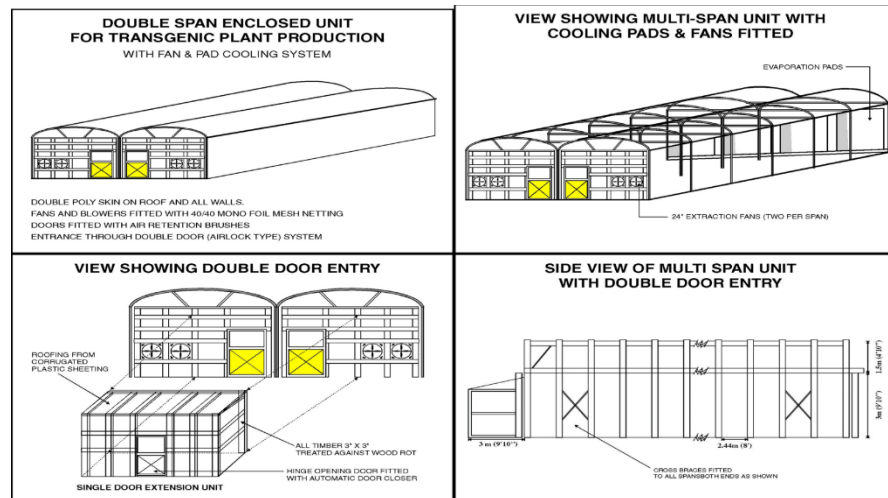
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Proposed positioning:

The location and the orientation of the unit is of significant importance. The fans should not be positioned in a manner that they blow directly towards the plants. Electricity and water are continuously required. Therefore these must be positioned within a reasonable reach of the unit to keep costs down. The area selected for the unit must be flat, and as far as possible leveled to accommodate the unit plus approximately 2 metres off around the outside. It would be useful to provide a drainage system around the unit at suitable lower levels to enable the drainage of extra water. A suitable drain off area is also recommended to enable the extra water running off from the gutters; the drain off area may be more than 10 metres away from the unit.

Views showing the Different aspects of Playhouse/Greenhouse:

Five diagrams showing schematically one recommended unit of the dimension 30 meters X 13 meters X 3 meters (Length X Breadth X Gutter height, excluding the dome height) are appended at enclosures I to V. The installers can install units bigger than the one suggested above. However, they have to ensure that all the safety precautions namely, installation of double doors, use of durable structures for the framework, use of at least 200 micron (800 gauge) plastic films in double coverings are used in the construction. Further, all the outlets would have to be secured by applying 40X40 mesh durable plastic coverings as indicated above.



Check your Progress

1. Write short notes on flavr savr Tomato
2. Discuss briefly about case study on Basmati rice
3. Explain about patent of Neem
4. Describe the case model studies of Turmeric
- 5 Give an account on general guidelines for research in transgenic plants

Flavr savr™ tomato as a model case for gm food

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11.9 LET US SUM UP

In this block, you have learnt about the intellectual property rights includes principles, types, general agreement on trade and tariff and world trade organization and also deals with plant biotechnological examples of patents, trade mark, trade secret and copy right and plant breeder's rights etc. Genetically modified plants are flavr savr tomato, basmati rice, neem and turmeric also discussed.

11.10 UNIT – END EXERCISES

1. Plant biotechnological examples of patents, trademark, trade secret etc.
2. Case studies on patents basmati, tomato, neem and turmeric

11.11 ANSWERS TO CHECK YOUR PROGRESS

1. Flavr Savr (also known as CGN-89564-2; pronounced "flavor saver"), a genetically modified tomato, was the first commercially grown genetically engineered food to be granted a license for human consumption. The FLAVR SAVR™ tomato was developed through the use of antisense RNA to regulate the expression of the enzyme polygalacturonase (PG) in ripening tomato fruit.

2. The Case Issue In the late 1997, when an American company RiceTec Inc. was granted a patent by the US patent office to call the aromatic rice grown outside India "Basmati", India objected to it. They used inbreeding of ordinary American rice with sub continental Basmati rice and patented this hybrid as Basmati RiceTec Inc. Patent Claims, Patent Advantage to RiceTech RiceTec able to not only call its aromatic rice Basmati within the US, but also label it Basmati for its exports.

3. Patent for Neem was first filed by W.R. Grace and the Department of Agriculture, USA in European Patent Office. The said patent is a method of controlling fungi on plants comprising of contacting the fungi with a Neem oil formulation. The EPO identified the lack of novelty, inventive step and possibly form a relevant prior art and revoked

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the patent. Apart from this, several US patents were recently taken out on Neem-based emulsions and solutions.

4. In 1995, the United States awarded patent on turmeric to University of Mississippi medical center for wound healing property. The claimed subject matter was the use of "turmeric powder and its administration", both oral as well as topical, for wound healing. An exclusive right has been granted to sell and distribute. The Indian Council for Scientific and Industrial Research (CSIR) had objected to the patent granted and provided documented evidences of the prior art to USPTO.

5. The current guidelines cover areas of recombinant DNA research on plants including the development of transgenic plants and their growth in soil for molecular and field evaluation. The guidelines also deal with import and shipment of genetically modified plants for research use only.

11.12 SUGGESTED READINGS

1. Biber – Klemm and T. Cottier, 2006, Rights of plants genetics resources and traditional knowledge: Basic issues and Perspectives, Cabi Publication, ISBN: 9780851990330

UNIT- 12 GENERAL ACCOUNT ON ECONOMIC BOTANY

Structure

- 12.1 Introduction
- 12.2 Objectives
- 12.3 General account on economic botany Origin and History,
- 12.4 Botanical description,
- 12.5 Cultivation and uses of Spices and Condiments:
 - 12.5.1 Ginger
 - 12.5.2 Turmeric
 - 12.5.3 Clove
 - 12.5.4 Chilli
 - 12.5.5 Pepper
 - 12.5.6 Coriander
- 12.6 Spices obtained from Seeds
 - 12.6.1 Cardamom,
 - 12.6.2 Nuts
 - 12.6.2 Nut-meg
- 12.7 Let us sum up
- 12.8 Unit end Exercises
- 12.9 Answer to check your progress
- 12.10 Suggested readings

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12.1 INTRODUCTION

The history of botany examines the human effort to understand life on Earth by tracing the historical development of the discipline of botany—that part of natural science dealing with organisms traditionally treated as plants. Economic Botany is the interaction of people with plants. Economic botany is closely related to the field of ethnobotany, that word is based on two Greek roots: ethnos (race: people: cultural group) and botanikos (of herbs) and can mean the plant lore of a race or people as well as the study of that lore.

12.2 OBJECTIVES

- To study the history and importance of economic botany
- To study about Botanical description, Cultivation and uses of Spices and Condiments: Ginger, Pepper, Cardamom, Clove, Nut-Meg, Chilly, Coriandrum, and Turmeric.

12.3 GENERAL ACCOUNT ON ECONOMIC BOTANY, ORIGIN AND HISTORY

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Economic Botany is the interaction of people with plants. Economic botany is closely related to the field of ethnobotany. That word is based on two Greek roots: *ethnos* (race: people: cultural group) and *botanikos* (of herbs) and can mean the plant lore of a race or people as well as the study of that lore.

Economic botanists are scientists who study the interactions between humans and plants. That makes the field of Economic Botany as far flung and diverse as both the human and plant life on our planet. Economic botanists study human-plant interactions from a variety of different angles. These skilled researchers rely on a variety of disciplines including archeology, sociology, and ecology in addition to basic botany to help them explain these interactions and their effects on plants, society and our dynamic planet.



Knowledge Systems:

Economic Botany sometimes focuses on the processes as well as the products involved in plant cultivation. Scientists ask questions about how knowledge of useful plants is acquired and transmitted between groups.

In the South American Andes, potatoes are the staple of many indigenous diets. Economic botanists are intrigued by the questions of who first ate this vegetable and why they thought it might be appetizing and nutritious in spite of the fact that the leaves and stems of the potato plant are poisonous.

What made these cultures think that there might be something worth while lying beneath the surface? How did they share their knowledge and with whom?

Uses of Plants:

We can also study how plants are used. In the past this has meant lists of cultures and their preferred plant sources for food, clothing, shelter, medicine, ritual or aesthetics. Although there are roughly 250,000 species of plants divided into 460 families, we commonly use products from only 300 species in 20 of those families; just a tiny fraction of what's available.

Often a single plant will fill more than one function. The coconut palm is an excellent example of botanical versatility. It is found in cultivation throughout the tropics where it is known by many names including pokok seribu guna or 'tree of a thousand uses' in Malay. All parts of the plant are used from the leaves that are woven into thatch roofs and mats to the delicious fruit and sap right down to the roots that are processed to treat everything from dysentery to bad breath.

Today, economic botanists continue cataloguing plant uses, but they also hope to discover new ones by screening for medicines such as anti-cancer agents or experimenting with ways to improve current cultivation and make it more sustainable or efficient.

Ecology, Evolution and Systematics

Studies of the evolution of cultivated plants include the processes of domestication and the relationship between natural and human selection of specific plant traits. Knowledge of botany is essential to understanding how domestication may have changed a plant species over time. In addition, ethnobotanists look for help from such disciplines as history, archeology and even linguistics to shed light on this process.

Take maize as an example. Botanically speaking, physical evidence, including DNA and similar morphology of stems and grains has shown that maize is related to wild grasses in Central America and Mexico. This agrees with what history and archeology tell us about how this crop was first cultivated there as early as 7000 years ago. The name also gives clues to the crop's movement across cultures. Maize is the Spanish version of an Arawak word ma-hiz. The Spanish first encountered this grain in the Caribbean Islands and then introduced it to Europe; starting its eventual spread around the globe.

12.4 BOTANICAL DESCRIPTION

12.4.1 Botanical description of Ginger: *Zingiber officinale*. Zingiberaceae. Ginger are aromatic herb with an underground rhizome and an erect stem, up to 75 cm. in height,. Leaves of ginger are simple, alternate, linear-lanceolate, sheathing at the base, sessile, acuminate at apex, glabrous, up to 15 cm. long. Inflorescence a spike on a distinct scape; flowers densely arranged, bisexual, irregular, each subtended by a persistent scarious bract. Calyx tubular shortly 3-lobed; corolla bilabiate, tubular below, yellow with purplish spots stamens 3 in one whorl, one of which is perfect the

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other 2 united to form a labellum; filament of perfect stamen short, anther cells contiguous, connective produced into a beak, ovary of 3 carpels, syncarpous, 3-celled, inferior; ovules many on axile placentas; style filiform, lying in a groove of the anther; stigma subglobose.

Fruit an oblong capsule, many seeded; seeds arillate, globose, with a small embryo and copious endosperm.

12.4.2 Botanical description of Turmeric: An upright, perennial herb to about 1 m tall. The rhizome (underground stem) is thick and ringed with the bases of old leaves. Turmeric only reproduces via its rhizomes.

Leaves: Large, oblong, up to 1 m long, dark green on upper surface, pale green beneath. Each leafy shoot (pseudostem) bearing 8-12 leaves.

Flowers: Yellow-white, borne on a spike-like stalk 10-15 cm long. Flowers are sterile and do not produce viable seed.

Seeds: Small, ovoid, brown. Not viable.

12.4.3 Botanical description of clove: Cloves are the aromatic dried flower buds of a tree in the family Myrtaceae, *Syzygium aromaticum*. Cloves are native to the Maluku islands in Indonesia and used as a spice in cuisines all over the world. Cloves are harvested primarily in Indonesia, India, Madagascar, Zanzibar, Pakistan, and Sri Lanka. They have a numbing effect on mouth tissues.

The clove tree is an evergreen that grows to a height ranging from 8–12 m, having large leaves and sanguine flowers in numerous groups of terminal clusters. The flower buds are at first of a pale color and gradually become green, after which they develop into a bright red, when they are ready for collecting. Cloves are harvested when 1.5–2 cm long, and consist of a long calyx, terminating in four spreading sepals, and four unopened petals which form a small ball in the center.

12.4.4 Botanical description of Chilli: Chilli is a fruit of the plants '*Capsicum annum*' and '*Capsicum frutescens*' that come from the genus '*Capsicum*,' belonging to the family of '*Solanaceae*,' which also includes tomato and potato. Chilli Plant is an annual sub-herb and the fruits vary in shape, size, colour and degree of pungency. Capsicum plants are herbaceous or semi-woody annuals or perennials. The leaves are ovate, tapering to a sharp point, measuring up to 15 cm, dark green on the upper surface and pale green on the lower surface. The flowers are small, white and borne singly or in clusters of 2 or 3 in the axils of the leaves. The fruits are of diverse shapes and sizes depending upon the variety.

12.4.5 Botanical description of Pepper: *Piper nigrum* L. Taxonomic synonym: *Piper aromaticum* Lam. Family: Piperaceae.

Habitat: tropical plant native to India, where it is estimated it was first domesticated. *Piper nigrum* is a species coming after its congener *Piper longum*. Pepper gained great popularity in the tenth and twelfth centuries, when the Arabs opened the Spice Route between India and Europe.

Currently, pepper stands out as the most valuable species and with the biggest trade volume of cultivated species.

Leaves of pepper are petiolate, simple, alternate, limbo hard, oval, leathery. They are between 8 and 24 inches long by 12.5 wide (depending on variety). Petiole length of 1.5 centimeters. The leaves are dark green on the upper, and whitish-green on the underside. Each leaf has a midrib from which two or three pairs of opposite lateral veins spring.

12.4.6 Botanical description of Coriander: Coriander is native to regions spanning from Southern Europe and Northern Africa to Southwestern Asia. It is a soft plant growing to 50 cm (20 in) tall. The leaves are variable in shape, broadly lobed at the base of the plant, and slender and feathery higher on the flowering stems. The flowers are borne in small umbels, white or very pale pink, asymmetrical, with the petals pointing away from the center of the umbel longer (5–6 mm or 0.20–0.24 in) than those pointing toward it (only 1–3 mm or 0.039–0.118 in long). The fruit is a globular, dry schizocarp 3–5 mm (0.12–0.20 in) in diameter. Pollen size is approximately 33 microns.

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12.5 CULTIVATION AND USES OF SPICES AND CONDIMENTS

The story of spices, condiments, and the other flavouring materials is one of the most romantic chapters in the history of vegetable products. From the earliest time spices have been as eagerly sought after as gold. The craving for spices has been one of the great factors in human progress, and has done much to change the course of history and geography and to promote international relations. The discovery of new lands and of shorter trade routes and the colonization of spice-producing countries have resulted, in part, from this interest in aromatic plants. The quest for spices created a furore comparable only to the Crusades, and was one of the dominant factors in European history during the Middle Ages and as late as the sixteenth century. The use and cultivation of spices, however, go back to the beginnings of history. They have played a prominent part in all the civilizations of antiquity, in ancient China and India, in Babylon and Egypt, and in Greece and Rome.

The majority of spices originated in the Asiatic tropics and were among the first objects of commerce between the East and the West. The first traders were the Arabs, who brought the products of southern India and the Spice Islands by caravan to Arabia, and thence to Europe. Later other countries took over the spice trade. For many years Venice was the leader. In the sixteenth century the Portuguese assumed control and held a virtual monopoly for 200 years. They were supplanted by the Dutch, who were supreme for many years. Today the British Empire shares with Holland most of the spice trade of the world. In the olden days spices were put to many uses. They not only served to season insipid foods and

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give zest to an otherwise monotonous diet, but acted as preservatives as well. Their aromatic qualities were useful in overcoming the odors of bad food and unwashed humanity. They were used in beverages, in medicine, and even in lieu of money. Sought after by rich and poor alike, and expensive because of the demand and the difficulty of obtaining them, they were the basis of many great fortunes made between 1300 and 1700 A.D. The use of spices is not so widespread at the present time, but the United States still pays from \$10,000,000 to \$20,000,000 annually for crude spices, which are worth twice as much in the retail trade. The practice of importing the various aromatic substance in a crude state (Fig.1) and converting them into a powdered form is still followed in an attempt to prevent adulteration and to insure the quality of the final product. Essential oils, obtained from these aromatics, are also imported in large amounts. Spices be classed as foods, for they contain little of nutritive value. They do, however, give an agreeable flavor and aroma to food, and add greatly to the pleasure of eating. Stimulate the appetite and increase the flow of the gastric juices. For this reason they are often referred to as food accessories or adjuncts. Whatever value they have is due to the presence of the essential oils, and occasionally to other aromatic principles.

The medicinal value of spices is not so great as was thought during the Middle Ages, but a considerable number of them are still official drugs in both Europe and America. They are used as carminatives and antiseptics and to disguise the unpleasant taste of other drugs. They also play an important part in many of the industries and are used in perfumery, soaps, incense, as dyes, in histology, and in various arts. The majority of spices are still obtained from the tropics, chiefly from Asia. Africa supplies the grains of paradise, while tropical America furnishes vanilla, red pepper, and allspice. A small number occur in the cooler temperate regions of the Old World. The classification of spices, as in the case of all plant product that contain essential oils, is very difficult and there are no sharp boundaries between the various groups. Usually all aromatic vegetable products that are used for flavoring foods and drinks are included- under spices. In other cases, the term "spice" is restricted to hard or hardened parts of plants, which are usually used in a pulverized state. Condiment are spices or other flavoring substances that have a sharp taste, and are usually added to food after it has been cooked. Savory seeds are small fruits or seeds that are used whole. In the sweet or savory herbs, fresh or dried leaves are used for flavoring or garnishing. Essences are aqueous or alcoholic extractions of the essential oils. In view of the difficulty of distinguishing between spices, condiments, and the other flavoring materials, it seems best to consider this group on a morphological basis-the nature of the plant part utilized of the hundreds of spices that are used today, only a few can be discussed. These will be treated under roots, barks, buds and flowers, fruits, seeds, and leaves and stems.

12.5.1 GINGER

Ginger is the most important of the spices obtained from roots. ~ It has had a long and interesting history. A native of South eastern Asia, it was early used in China and India" and was brought by caravans to Asia Minor before the time of Rome. It was among the first of the oriental spices to be known in Europe, where it was prominent early in the middle Ages. For many years it was an important drug. It was the principal ingredient of a remedy for the plague, which was much used in England during the reign of Henry VIII. Today ginger is cultivated over a wider area than most spices, owing probably to the ease which the roots can be transported. The ginger plant (*Zingiber' officinale*) is an erect perennial herb (Fig. 1) with thick scaly rhizomes that branch digitately and are known as "hands." The stem reaches a height of 3 ft. and is surrounded by the sheathing bases of the leaves. The flowers are borne in a spike with greenish-yellow bracts subtending the yellowish flowers, which have a purple lip. Ginger is cultivated for the most part in small home gardens. A rich moist soil, partial shade, and a strictly tropical climate are desirable. The plant is propagated by the rhizomes. The rhizomes are pale yellow in color externally and a greenish yellow inside. They contain starch, gums, an oleoresin, and an essential oil as well. The several varieties differ in the content of the latter two principles. The rhizomes are dug after the aerial parts of the plant have withered. Ginger is prepared in two different ways. Preserved or green' ginger is a product of southern China. Young juicy rhizomes are dried, cleaned, and boiled in water until tender. They are then peeled, scraped, and boiled several times in a sugar solution, and finally packed in a similar solution. Occasionally preserved ginger is prepared in a dry state by dusting the drying rhizomes with powdered sugar.

Dried or cured ginger is the product of the other ginger-growing countries. The rhizomes are cleaned, carefully peeled, and' dried in the sun. They are sometimes parboiled in water or ' lime juice before peeling. This is the black ginger of commerce. White ginger is made by bleaching the rhizomes. The aromatic odor of ginger is due to the essential oil, while the pungent taste is due to the presence of the non volatile oleoresin, gingerin. Ginger is used more as a condiment than as a spice. It dilates the blood vessels in the skin, causing a feeling of warmth, and increases perspiration, with an accompanying drop in temperature. For this reason it is much used in warm countries. In medicine, ginger is used as a carminative and a digestive' stimulant. It is extensively used in culinary preparations, such as soups, puddings, pickles, gingerbread, and cookies, and is an ingredient of all curries, except those used with fish. Ginger is exceedi popular for flavoring beverages, such as ginger ale and ginger beer. It was formerly used for spicing wine and porter. The

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oleoresin is extracted and used in medicine and flavoring. The essential oil is also extracted. As this lacks pungency, cayenne pepper is usually added when it is used for flavoring purposes. Ginger is grown chiefly in China, Japan, Sierra Leone, Jamaica, Queensland, and the Dutch East Indies. The United States imports crystallized ginger from China and dried ginger from Jamaica, India, and Sierra Leone.



Fig.1 Ginger

12.5.2 TURMERIC

Turmeric (*Curcuma longa*) combines the properties of a dyestuff and a spice, and has already been discussed in the former connection. It is native to Cochin China and is widely cultivated in the tropics of both hemispheres. Turmeric is especially popular in India, where 60,000 acres are devoted to it, and enormous quantities are used, as they have been for centuries. The plant is a robust perennial with a short stem and tufted leaves. The pale-yellow flowers are borne in dense spikes, topped by a tuft of pinkish bracts. The rhizomes, which are the source of the color ful condiment, are short and thick, with blunt tubers. They are cleaned, washed, and dried in the sun. Turmeric is very aromatic with a musky odor, and has a pungent bitter taste. It is used to flavor, and at the same time color, butter, cheese, pickles, and other foodstuffs. A considerable quantity is exported to Europe and America for this purpose. Turmeric is one of the principal ingredients of curry. Curry is not a single substance, but a compound of many spices. Each type of meat or other food requires its own particular curry. One popular recipe for a meat curry includes turmeric, coriander, cinnamon, cumin, ginger, cardamom, fenugreek, cayenne pepper, pimiento, black pepper, long pepper, cloves, and nutmeg. Another curry, used for fish, is made from turmeric, coriander, black pepper, cumin, cayenne pepper, and fenugreek.



Turmeric

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12.5.3 CLOVES

Cloves are one of the most important and uses the spices. They were in use as early as the third century B.C' .in, well-known to the Romans, and reached Europe during the Middle Age. Their source and place of origin were unknown until the Portuguese discovered the Molucca Islands in the sixteenth century. For a time cloves were a Portuguese and later a Dutch monopoly. Today they are grown in many tropical countries in both the Old and New Worlds. Cloves are the unopened flower buds of *Eugenia caryophyllata*, a small, conical, and "gery, symmetrical evergreen tree'. In the wild state it produces clusters of crimson flowers, but in cultivation (Fig. 203) it never reaches the flowering state. The flower bud are greenish or reddish when fresh and become brown and brittle on drying. Their shape is nail-like, and the name" clove" is derived from the French word for nail, clour. They have a slightly cylindrical base, surmounted by the plump, ball-like, unopened corolla, which is surrounded by the four-toothed calyx. The cloves (Fig. 3) are picked by hand and dried in the sun or by artificial means. The' crop is an uncertain one and is hard to grow. Cuttings are cloves and the seeds germinate and grow slowly. The yield is rather low. Considerable moisture in the soil is necessary, and there is an old saying that clove trees must be able" to see the sea." Cloves are very aromatic and fine flavored. They' have almost endless uses, both whole and in the ground state, as a culina'ry spice, for the flavor blends well with both sweet and savory dishes. They are used for flavoring pickles, ketchup, and sauces; in medicine; and for perfuming the breath and the air in rooms, the essential oil, which is obtained by distilling cloves with water or steam, has even more uses. It is used in medicine as an aid to digestion and for its antiseptic~and antispasmodic action. It is often used as a local antiseptic in toothache, externallyit, has a counterirritant action. It is an ingredient of many tooth pastes and mouthwashes. The oil has many industrial applications and is extensively employed in perfumes, in scenting soap, and as a clearing agent in histological work. The chief constituent of the oil, eugenol, is extracted and used as an imitation carnation in perfumes and for the formation of artificial vanilla. Clove stems are a commercial product, with a small content of the essential oil, and they are often used to adulterate cloves. The dried fruits, known as mother cloves, are also of some value. The ehief clove-producing

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countries are Zanzibar, which grows -90 per cent of the total output, the Dutch East Indies, Mauritius, Java, and the West Indies.



Clove

12.5.4 CHILLY

Capsicum annum most important distribution to the spices is capsicum or red pepper. This familiar condiment is obtained from the fruits of several different plants, all belonging to the genus *Capsicum*. This genus is native to tropical America and the West Indies. The capsicums are very old, extending back to pre-Inca days. Shortly after the voyages of Columbus, who found all the West Indian natives using red pepper the spice reached Europe, and by 1600 it was widespread in the Eastern tropics. Today capsicums are grown all over the world, except in the colder parts, and in many countries they are the most important spice. The long period of cultivation has resulted in many varieties, (. . . differing in habit and in the size, shape, color, and pungency of the fruit. Among these are the bell peppers, chilis, paprikas, pimientos, tabascos, and others. By some authorities these are considered to belong to two or three distinct species, while others interpret them as derivatives of a single species, known variously as *Capsicum frutescens* or *C. annum*. The sweet or bell peppers (var. *grossum*) are herbs or slightly woody plants, 2 or 3 ft. in height, with ovate leaves, white flowers with a rotate corolla, and many-seeded fleshy fruits, which are technically berries. The fruits (Fig. 205) are large and puffy with a depression at the base, and are yellow or red in color when ripe. These peppers are the mildest of all the capsicums, as the pungent principle is restricted to the seeds. They are more favored in the northern part of the United States, where they are used as a fruit vegetable rather than as a spice. Both green and ripe peppers are eaten raw in salads, or are cooked in various ways, stuffed peppers being especially popular. They are also used in pickles. The plants are grown as annuals or biennials, depending on the climate. They require a long season in which to develop, but even so are well adapted to cooler areas, for they will withstand a little frost. The paprikas are European varieties with large mild fruits. Spanish paprika, which is better known as pimiento, produces attractive fruits with a characteristic flavor, but entirely lacking in pungency. These are preserved, and are used in cheese preparations and stuffed olives. They are also grown in California and Georgia.

Hungarian paprika has long pointed fruits which are more pungent. These are dried and used for powdered paprika, which is a familiar condiment. Several grades are prepared, differing in pungency. Only the pericarps and seeds are used. The uses of paprika as a condiment and in cooking are too well-known to need mention. Perhaps the best known dish, in which paprika is an essential element, is Hungarian goulash. The chills (var. longum) or capsicums, as they are known in medicine, are strictly tropical and subtropical plants. They are more woody and taller, with small pod like berries and innumerable small flat seeds. The crimson or orange-red fruits (Fig. 199, G) are elongate, conical, somewhat flattened, and very pungent. The pungent principles are present in the flesh and rind as well as the seeds. These peppers are cultivated every where in the tropics. The African varieties are the hottest, but Japanese chilis are more favored for culinary purposes. The ripe fruits are dried in the sun and used whole or powdered. The ground fruits constitute the cayenne pepper or red pepper of commerce. Capsicum is used in medicine internally as a powerful stimulant and carminative and to prevent fever; it is used externally as a counterirritant. It is extensively used in such beverages as ginger ale because of its pungency. The culinary uses are too numerous to mention. These small peppers are especially favored in the American tropics, where they are used in chili con carne, tamales, and other local dishes. Pepper sauce is made by extracting the pulp by pressure and pickling in brine or strong vinegar. Tabasco sauce is pepper sauce made from a small variety grown in Louisiana. The United States imports paprika from Hungary, and capsicum chiefly from Japan, British East Africa, and Mexico.

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Chilly

12.5.5 PEPPER

Pepper has always been one of the most important of spices, and it is one of the most ancient. It has been highly esteemed in the East from time immemorial. It was an important commodity in Greece and Rome, and was the chief spice during the middle Ages, when tributes were often levied in pepper. As early as 1180 the Guild of Pepperers was one of the leading trade guilds in England. It is interesting to note that London is still the center of the pepper trade. The high price of pepper was one of the chief incentives for the search for a sea route to India. Today no other spice is better known or more widely used. Black pepper is the dried unripe fruit of *Piper nigrum*, a vine indigenous to India or the Indo-Malayan region. It is now cultivated everywhere in the Eastern tropics from Africa to India, Siam, the Philippine Islands, the East Indies, and the South Sea Islands. The pepper plant is a weak climbing or trailing

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shrub with adventitious roots, reaching a length of 30 ft. in the wild state. It has coriaceous evergreen leaves and very small flowers in catkins. The fruits are small one-seeded berrylike drupes, about 50 to a catkin. In ripening they change in color from green to bright red and then to yellow. Pepper requires a hot humid climate and at least partial shade. Various soils can be utilized. The plants are supported on posts or living trees. When they are about 2 ft. in height, the tip is removed to promote the development of lateral buds. The crop begins to yield in two or three years and reaches full bearing in seven years. Propagation is by seed or cuttings from the tips of the vines. For the preparation of the black pepper of commerce the fruits are gathered when at least a few of the berries in each spike are red. They are picked by hand. The spikes are dried in the sun or in smoke and are sometimes treated with boiling water preparatory to drying. When dry, the berries or peppercorns are rubbed off, winnowed, and packed for shipment. They are reddish brown or black with ~ wrinkled surface and measure 3-5 mm. in diameter. White pepper is prepared from berries that are nearly ripe. They are picked and piled in heaps to ferment or are soaked in water. The pulp and outer coating of the seed are then removed. White pepper is a yellowish-grey color, and the surface is smooth.

Frequently white pepper is prepared from black peppercorns by grinding off the outer parts by machinery. Although not so pungent as black pepper, white pepper is preferred in the trade. Commercial ground pepper is often a blend. The aromatic odor of pepper is due to a volatile oil, while the pungent taste is caused by an oleoresin. An alkaloid is also present. Pepper stimulates the flow of saliva and the gastric juices and has a cooling effect. The culinary uses are numerous, and it is especially valuable as a condiment. Pepper itself as well as the oleoresin and alkaloid are used in medicine. The alkaloid is used as a source of synthetic heliotrope. The United States imports more pepper than any other spice. Long Pepper Long pepper is obtained from *Piper retrofractum* of Java and *Piper longum* of India. The former species, a climbing woody plant native to Malaya, is cultivated in Java, Bali, and adjacent islands. The latter is shrubbier. It is a native of India, Ceylon, and the Philippine Islands, and is grown chiefly in Bengal. Long pepper was more highly esteemed by the Romans than black pepper and was also important in the middle Ages. The tiny fruits are fused into cylindrical spikelike (loncs. These are collected when unripe and are dried quickly in the sun or over fires. Long pepper contains the same principles as black pepper, but is very aromatic and somewhat sweeter. It is grown in the same way as the ordinary pepper. It is almost a forgotten spice, except in the tropics, where it is extensively used in pickles, preserves, and curries.



Pepper

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12.5.6 CORIANDER

Coriander is another very old flavoring substance. It is mentioned in Egyptian, Sanskrit, Hebrew, and Roman literature. During the middle Ages it had many curious uses, such as locomotion, incense, etc. The plant (*Coriandrum sativum*) is a native of the Mediterranean region, and is extensively grown in Europe, Morocco, and India. It is a rank-smelling perennial, 3 ft. in height, with small white or pinkish flowers. The lower leaves have broad segments, while the upper are very narrow. The globular yellow-brown fruits (Fig. 208, A) have an unpleasant odor when fresh. The dried fruits, however, are pleasantly aromatic and serve as a common flavoring substance for both sweet and savory dishes, especially in Europe and India. The fruits are often candied in a sugar solution and sold as "sugar plums." Oil of coriander is used in medicine and in flavoring beverages, such as gin, whisky, and various liqueurs. The extract or essence is a better flavoring substance than either the dried fruit or the oil.



Coriander

12.6 SPICES OBTAINED FROM SEEDS

12.6.1 CARDAMOM

Cardamom For centuries the highly aromatic seeds of the cardamom (*Elettaria Cardamomum*) have been an important spice in the Orient. The plant is a native of India, and is cultivated chiefly in that country and Ceylon, although it has been introduced into other tropical countries. It is a perennial herb, 6 to 12 ft. in height, with long lanceolate leaves with sheathing bases. The white flowers, with a blue and yellow lip, are borne on a separate elongated stalk. The fruits, which are triangular capsules, are borne the year round. The small seeds (Fig. 199, A) are light colored and have a delicate flavor. They are usually kept in the fruit until needed, for the flavor is better. In other cases, seeds of either wild or cultivated plants are gathered when dead ripe and dried in the sun. Cardamoms are used in curries, cakes, pickles, and for other

culinary purposes, as well as in medicine. They are a favorite masticatory in India. The oil is used somewhat in cooking and in flavoring beverages.



Cardamom

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12.6.2 NUTS

Very few botanical terms are used more loosely than "nut." Technically a nut is a one-celled, one-seeded dry fruit with a hard pericarp (shell). A few of the so-called nuts of commerce answer this description. Among them are the acorn, chestnut, filbert, and hazelnut. The others may be seeds, as the Brazil nut; legumes, like the peanut; or dry drupes from which the outer parts of the fruit have been removed, such as the almond, coconut, pecan, and walnut. For convenience all these "nuts" will be considered together, regardless of their morphological nature. Nuts are a valuable food material, and have been used as such for a long time, although in the United States they have been considered more as a confection until comparatively recently. Nuts are inexpensive, for they are produced in abundance and are easy to obtain. Because of their low water content they are a concentrated food, and also keep and handle well. They can withstand transport (tension, rough handling, and low temperature. If kept cool they rarely spoil; otherwise they may deteriorate by becoming wormy, rancid, or musty. The food value of nuts is due chiefly to a high protein and fat content. However, they also contain starch, and sometimes sugar, and so furnish a well-balanced diet. For some reason, chiefly lack of knowledge, nuts have been considered indigestible. As a matter of fact, the reverse is true, and they are used as food by thousands of people, especially in the tropics where meat is scarce. Unless nuts, like any other food, are eaten in too large quantities, they are harmless. They may be eaten raw or cooked, or in the form of nut butters and pastes. They are often ground up to serve as coffee substitutes. Nuts are marketed in the shell or shelled. The former are often bleached, polished, or stained for the sake of appearance. The latter are apt to collect dirt in the crevices, and should be thoroughly cleaned before using. Owing to the increasing value of nuts and the readiness with which nut-bearing trees can be grown on nonagricultural land, considerable attention is being directed to them with a view to improvement. Experiments are being carried on in

selection and hybridization, which promise important results. 'In general, three groups of nuts can be recognized: those with a high fat content, those with a high protein content, and those with a high carbohydrate content.

12.6.2 NutMeg

Nutmeg and mace are both obtained from *Myristica fragrans*, a native of the Moluccas or Spice Islands, and now grown in the tropics of both hemispheres. It is doubtful whether these spices, which are now so popular, were known to the ancients. They had reached Europe, however, by the twelfth century. Upon the discovery of the Spice Islands in 1512, the Portuguese obtained a monopoly of nutmeg and mace, which was later wrested from them by the Dutch. At a later date trees were smuggled into French and British possessions and the monopoly was broke up. The nutmeg tree is a handsome evergreen with dark leaves and reaches a height of 30 to 60 ft. It is normally dioecious, with small pale-yellow flowers that are fleshy and aromatic. The ripe fruits (Fig. 7) are golden-yellow and resemble apricots or pears. They gradually dry out and, when dead ripe, the husk splits open revealing the shiny brown seed covered with a brightred banching aril. Inside the seed is the kernel, which is the nutmeg of commerce. The aril is the source of mace. The nutmeg is propagated from seed in nurseries aftd later transplanted. It requires a hot moist climate and thrives best when near the sea, so that islands are very favorable for its growth. The trees come into full bearing when about 15 years of age and continue for 10 or 20 years. The yield is very high, a large tree furnishing from 3000 to 10,000 nutmegs annually. Fruits are produced all the year round. After the husks split open, the' fruits are picked, the pericarp is removed, and the mace is stripped from the shell, flattened, and qried. It turns a yellowish brown. The seeds are dried and the she'll crack off. The kernels are remove'd, sortf'd, and often treated with lime to prevent insect attack. Mace is one of the most delieately flavored of spices and is used with savory dishes and in making pickles, ketchup, and sauces. Nutmegs have been utled medicinally and as a culinary spice for a long time. Grated nutmeg is used with puddings, custards, and other sweet dishes, and with various beverages. A jelly is made from the fresh husks of the ripe fruit. An essential oil is extracted for use in medicine and as a flavoring agent. This oil contains a highly toxic substance, myristicin, and can be used only in small amounts. Caution must also be exercised in the use of nutmeg and mace. Nutmeg oil is also used in the perfume and tobacco industries.

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Myristica fragrans

Check your progress

1. Give an account on economic importance of Pepper and Chilly
2. List out different uses of Turmeric

12.8 LET US SUM UP

In this unit you have learnt about the general account on economic botany and cultivation and uses of spices and condiments. And also discussed fibers and timbers and ethnobotany.

12.9 UNIT END EXERCISES

- Origin and history and cultivation of economic botany
- Botanical description, harvesting, extraction and uses of fatty oils and vegetable fats
-

12.10 ANSWER TO CHECK YOUR PROGRESS

1. Pepper stimulates the flow of saliva and the gastric juices and has a cooling effect. The culinary uses are numerous, and it is especially valuable as a condiment. The high price of pepper was one of the chief incentives for the search for a sea route to India.
Capsicum is used in medicine internally as a powerful stimulant and carminative and to prevent fever; it is used externally as a counterirritant. It is extensively used in such beverages as ginger ale because of its pungency. The culinary uses are too numerous to mention. These small peppers are especially favored in the American tropics, where they are used in chili con carne, tamales, and other local dishes.
2. Turmeric is very aromatic with a musky odor, and has a pungent bitter taste. It is used to flavor, and at the same time color, butter, cheese, pickles, and other foodstuffs. A considerable quantity is exported to Europe and America for this purpose. Turmeric is one of the principal ingredients of curry.
- 3.

12.11 SUGGESTED READINGS

1. Sambamurthy, 2008, A Textbook of Modern Economic Botany, 1st edition, CAS publishers & Distributors Pvt, Ltd, ISBN:8123906293
2. Ashwin Dutt, 2008, Economic Botany, 1st edition, Aahyayan Publishers & Distributors, ISBN: 8184350694

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UNIT- 13 BOTANICAL DESCRIPTION

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Structure

- 13.1 Introduction
- 13.2 Objectives
- 13.3 Origin and History,
- 13.4 Botanical description,
- 13.5 Harvesting,
- 13. 6 Extraction and uses of fatty oils
 - 13.6.1 Sun flower,
 - 13.6.2 Soya bean,
 - 13.6.3 Sesame oil
 - 13.6.4 Peanut oil
 - 13.6.5 Coconut oil
 - 13.6.6 Palm Oil,
- 13.7 Fibers and Timber:
 - 13.7.1 Cotton,
 - 13.7.2 San hemp,
 - 13.7.3 Teak,
 - 13.7.4 Fatty Oils
 - 13.7.5 Rosewood,
 - 13.7.6 Ebony,
 - 13.7.7 Sal and
 - 13.7.8 Mahogany
- 13.8 Let us sum up
- 13.9 Unit end Exercises
- 13.10 Answer to check your progress
- 13.11 Suggested readings

13.1 INTRODUCTION

Vegetable oils (and margarine, made from these oils) are oils extracted from seeds like the rapeseed (canola oil) soybean (soybean oil), corn, sunflower, safflower, etc. They were practically non-existent in our diets until the early 1900s when new chemical processes allowed them to be extracted. Wood fibres are usually cellulosic elements that are extracted from trees and used to make. The wood fibre can be extracted as a primary product, or collected during the milling of lumber. Wood fibres can also be recycled from used paper. Wood fibres can be pressed into hard, flat panels which can be used as a less expensive alternative to wood or plywood in situations not requiring structural strength. Wood fibres can be used as a substrate in hydroponics. The most common species of wood used for timber frame homes are white pine, red and white oak, and Douglas fir, cypress and cedar

13.2 OBJECTIVES

- To learn technique related to Harvesting, Extraction and uses of Fatty oils and vegetable oils
- To study about Fibers and Timber: Cotton, Jute, Sun hemp, Teak, Rosewood, Ebony, Sal and Mahogany.

13.3 ORIGIN AND HISTORY

Vegetable oils were early fuels tested in the compression ignition engine invented by Rudolf Diesel in the late 1800s. While on display at the 1900 Paris Exposition, Diesel's engine was fueled with peanut oil. From that time until the early 1950s, varying degrees of success were achieved when substituting vegetable oils either completely or partially for diesel fuel. The interest in vegetable oil fuels never gained widespread serious attention because of abundant supplies, stable markets, and low prices for petroleum, and so diesel engines were optimally designed to operate on petroleum distillates. However, in the early 1970s the Organization of Petroleum Exporting Countries (OPEC) began to limit supplies (popularly known as the OPEC Oil Embargo), and prices for petroleum rapidly escalated. Interest reemerged in vegetable oils as diesel fuel extenders because of fear of high petroleum prices and unstable Middle East politics. However, high petroleum prices did not persist, and as prices declined in the 1980s, so did interest in using vegetable oils as fuel. In recent years, however, interest has revived, because methyl esters of vegetable oils reduce atmospheric pollution and have other environmental benefits.

13.4 BOTANICAL DESCRIPTION

13.4.1 Botanical description of Sunflower: *Helianthus annuus*, the **common sunflower**, is a large annual forb of the genus *Helianthus* grown as a crop for its edible oil and edible fruits.

The plant has an erect rough-hairy stem, reaching typical heights of 3 metres (9.8 ft). The tallest sunflower on record achieved 9.17 metres (30.1 ft). Sunflower leaves are broad, coarsely toothed, rough and mostly alternate. What is often called the "flower" of the sunflower is actually a "flower head" or pseudanthium of numerous small individual five-petaled flowers ("florets"). The outer flowers, which resemble petals, are called ray flowers. Each "petal" consists of a ligule composed of fused petals of an asymmetrical ray flower. They are sexually sterile and may be yellow, red, orange, or other colors. The flowers in the center of the head are called disk flowers. These mature into fruit (sunflower "seeds"). The disk flowers are arranged spirally. Generally, each floret is oriented toward the next by approximately the golden angle, 137.5° , producing a pattern of interconnecting spirals, where the number of left spirals and

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the number of right spirals are successive Fibonacci numbers. Typically, there are 34 spirals in one direction and 55 in the other; however, in a very large sunflower head there could be 89 in one direction and 144 in the other. This pattern produces the most efficient packing of seeds mathematically possible within the flower head.

13.4.2 Botanical description of Soya bean: Soybean, *Glycine max*, is an herbaceous annual plant in the family Fabaceae grown for its edible seeds. The soybean plant is usually an erect bush with woody stems and alternately arranged leaves. The leaves possess three individual leaflets which are oval or lance-like in shape, growing to a length of 3–10 cm (1.2–4.0 in). The soybean plant produces small white or purple flowers and curved seed pods which are 3–15 cm (1.2–6 in) in length and can contain between 1 and 5 seeds. The seeds can be a variety of colors including yellow, green, brown, black or a mottled combination. Soybean is an annual plant, surviving only one growing season and can reach heights of 0.2–1.5 m (0.7–1.4 ft). Soybean may also be referred to as soyabean or soya and originates from Northeast China.

13.4.3 Botanical description of Sesame oil: (*Sesamum Indicum*)

It is an annual plant growing 50 to 100 cm (1.6 to 3.3 ft) tall, with opposite leaves 4 to 14 cm (1.6 to 5.5 in) long with an entire margin; they are broad lanceolate, to 5 cm (2 in) broad, at the base of the plant, narrowing to just 1 cm (0.4 in) broad on the flowering stem. The flowers are yellow, tubular, 3 to 5 cm (1.2 to 2.0 in) long, with a four-lobed mouth. The flowers may vary in colour with some being white, blue or purple.

Sesame fruit is a capsule, normally pubescent, rectangular in section and typically grooved with a short triangular beak. The length of the fruit capsule varies from 2 to 8 cm, its width varies between 0.5 to 2 cm, and the number of loculi from 4 to 12. The fruit naturally splits opens (dehiscence) to release the seeds by splitting along the septa from top to bottom or by means of two apical pores, depending on the varietal cultivar. The degree of dehiscence is of importance in breeding for mechanised harvesting as is the insertion height of the first capsule. Sesame seeds are small. The size, form and colours vary with the thousands of varieties now known. Typically, the seeds are about 3 to 4 millimeters long by 2 millimeters wide and 1 millimeter thick. The seeds are ovate, slightly flattened and somewhat thinner at the eye of the seed (hilum) than at the opposite end. The weight of the seeds is between 20 and 40 milligrams. The seed coat (testa) may be smooth or ribbed. Sesame seeds come in many colours depending on the cultivar harvested. The most traded variety of sesame is off-white coloured. Other common colours are buff, tan, gold, brown, reddish, gray and black. Sesame seed is sometimes sold with its seed coat removed (decorticated). This is the variety often present on top of buns in developed economies.

13.4.4 Botanical description of Peanut oil: Peanut, *Arachis hypogaea*, is an herbaceous annual plant in the family Fabaceae grown for its oil and

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edible nuts. Peanut plants are small, usually erect, thin stemmed plants with feather-like leaves. The leaves are arranged in alternate pairs and have leaf-like attachments near the stalk. The peanut plant produces yellow, orange, cream or white flowers which produce 'pegs', characteristic floral structures which sink into the ground to grow the pod. The pods can reach up to 10 cm (4 in) in length and can contain between 1 and 5 seeds. The peanut plant can reach 0.6 m (2 ft) in height depending on the variety and as an annual plant, survives only one growing season. Peanut may also be referred to as groundnut, monkeynut or earth nut and originates from South America.

13.4.5 Botanical description of Coconut oil: The coconut tree (*Cocos nucifera*) is a member of the palm tree family (Arecaceae) and the only known living species of the genus *Cocos*. The term "coconut" (or the archaic "cocoanut") can refer to the whole coconut palm, the seed, or the fruit, which botanically is a drupe, not a nut.

Cocos nucifera is a large palm, growing up to 30 m (98 ft) tall, with pinnate leaves 4–6 m (13–20 ft) long, and pinnae 60–90 cm (2–3 ft) long; old leaves break away cleanly, leaving the trunk smooth. Coconuts are generally classified into two general types: tall and dwarf. On fertile soil, a tall coconut palm tree can yield up to 75 fruits per year, but more often yields less than 30. Given proper care and growing conditions, coconut palms produce their first fruit in six to ten years, taking 15 to 20 years to reach peak production.

The palm produces both the female and male flowers on the same inflorescence; thus, the palm is monoecious. Other sources use the term polygamomonoecious. The female flower is much larger than the male flower. Flowering occurs continuously. Coconut palms are believed to be largely cross-pollinated, although some dwarf varieties are self-pollinating.

The endosperm is initially in its nuclear phase suspended within the coconut water. As development continues, cellular layers of endosperm deposit along the walls of the coconut, becoming the edible coconut "flesh". Botanically, the coconut fruit is a drupe, not a true nut. Like other fruits, it has three layers: the exocarp, mesocarp, and endocarp. The exocarp and mesocarp make up the "husk" of the coconuts. Coconuts sold in the shops of nontropical countries often have had the exocarp (outermost layer) removed. The mesocarp is composed of a fiber, called coir, which has many traditional and commercial uses. The shell has three germination pores (micropyles) or "eyes" that are clearly visible on its outside surface once the husk is removed.

A full-sized coconut weighs about 1.4 kg. It takes around 6,000 full-grown coconuts to produce one tonne of copra.

13.4.6 Botanical description of Palm oil:

Borassus flabelliferis is a robust tree and can reach a height of 30 metres (98 ft). The trunk is grey, robust and ringed with leaf scars; old leaves remain attached to the trunk for several years before falling cleanly. The

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leaves are fan-shaped and 3 m (9.8 ft) long, with robust black teeth on the petiole margins. Like all *Borassus* species, *B. flabellifer* is dioecious with male and female flowers on separate plants. The male flowers are less than 1 cm long and form semi-circular clusters, which are hidden beneath scale-like bracts within the catkin-like inflorescences. In contrast, the female flowers are golfball-sized and solitary, sitting upon the surface of the inflorescence axis. After pollination, these blooms develop into fleshy fruits 15–25 cm wide, each containing 1-3 seeds. The fruits are black to brown with sweet, fibrous pulp and each seed is enclosed within a woody endocarp. Young palmyra seedlings grow slowly, producing only a few leaves each year (establishment phase), but at an as yet undetermined time, they grow rapidly, producing a substantial stem.

13.5 HARVESTING

The principles dictating at which stage of maturity a fruit or vegetable should be harvested are crucial to its subsequent storage and marketable life and quality. Post-harvest physiologists distinguish three stages in the life span of fruits and vegetables: maturation, ripening, and senescence. Maturation is indicative of the fruit being ready for harvest. At this point, the edible part of the fruit or vegetable is fully developed in size, although it may not be ready for immediate consumption. Ripening follows or overlaps maturation, rendering the produce edible, as indicated by taste. Senescence is the last stage, characterized by natural degradation of the fruit or vegetable, as in loss of texture, flavour, etc. (senescence ends at the death of the tissue of the fruit). Some typical maturity indexes are described in following sections.

13.5.1 Skin colour:

This factor is commonly applied to fruits, since skin colour changes as fruit ripens or matures. Some fruits exhibit no perceptible colour change during maturation, depending on the type of fruit or vegetable. Assessment of harvest maturity by skin colour depends on the judgment of the harvester, but colour charts are available for cultivars, such as apples, tomatoes, peaches, chilli peppers, etc.

13.5.2 Optical methods:

Light transmission properties can be used to measure the degree of maturity of fruits. These methods are based on the chlorophyll content of the fruit, which is reduced during maturation. The fruit is exposed to a bright light, which is then switched off so that the fruit is in total darkness. Next, a sensor measures the amount of light emitted from the fruit, which is proportional to its chlorophyll content and thus its maturity.

13.5.3 Shape:

The shape of fruit can change during maturation and can be used as a characteristic to determine harvest maturity. For instance, a banana becomes more rounded in cross-sections and less angular as it develops

on the plant. Mangoes also change shape during maturation. As the mango matures on the tree the relationship between the shoulders of the fruit and the point at which the stalk is attached may change. The shoulders of immature mangoes slope away from the fruit stalk; however, on more mature mangoes the shoulders become level with the point of attachment, and with even more maturity the shoulders may be raised above this point.

13.5.4 Size:

Changes in the size of a crop while growing are frequently used to determine the time of harvest. For example, partially mature cobs of *Zea mays saccharata* are marketed as sweet corn, while even less mature and thus smaller cobs are marketed as baby corn. For bananas, the width of individual fingers can be used to determine harvest maturity. Usually a finger is placed midway along the bunch and its maximum width is measured with callipers; this is referred to as the calliper grade.

13.5.5 Aroma:

Most fruits synthesize volatile chemicals as they ripen. Such chemicals give fruit its characteristic odour and can be used to determine whether it is ripe or not. These odours may only be detectable by humans when a fruit is completely ripe, and therefore has limited use in commercial situations.

13.5.6 Fruit opening:

Some fruits may develop toxic compounds during ripening, such as ackee tree fruit, which contains toxic levels of hypoglycine. The fruit splits when it is fully mature, revealing black seeds on yellow arils. At this stage, it has been shown to contain minimal amounts of hypoglycine or none at all. This creates a problem in marketing; because the fruit is so mature, it will have a very short post-harvest life. Analysis of hypoglycine 'A' (hyp.) in ackee tree fruit revealed that the seed contained appreciable hyp. at all stages of maturity, at approximately 1000 ppm, while levels in the membrane mirrored those in the arils. This analysis supports earlier observations that unopened or partially opened ackee fruit should not be consumed, whereas fruit that opens naturally to over 15 mm of lobe separation poses little health hazard, provided the seed and membrane portions are removed. These observations agree with those of Brown et al. (1992) who stated that bright red, full sized ackee should never be forced open for human consumption.

13.5.7 Leaf changes:

Leaf quality often determines when fruits and vegetables should be harvested. In root crops, the condition of the leaves can likewise indicate the condition of the crop below ground. For example, if potatoes are to be stored, then the optimum harvest time is soon after the leaves and stems have died. If harvested earlier, the skins will be less resistant to harvesting and handling damage and more prone to storage diseases.

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13.5.8 Abscission:

As part of the natural development of a fruit an abscission layer is formed in the pedicel. For example, in cantaloupe melons, harvesting before the abscission layer is fully developed results in inferior flavoured fruit, compared to those left on the vine for the full period.

13.6 EXTRACTION AND USES OF FATTY OILS

Fatty oils another type of oil that occurs in plants is the fatty oil. The fatty oils are also called fixed oils because, unlike the essential oils, they do not evaporate or become volatile, and they cannot be distilled without being decomposed. Chemically these vegetable fatty oils are close to animal fats. They consist of glycerin in combination with a fatty acid. The so-called oils are liquid at ordinary temperatures and usually contain oleic acid. The fats, on the other hand, are solid at ordinary temperatures and contain stearic or palmitic acid. The fatty oils are insoluble in water, but soluble in various organic solvents. When fats break down, they yield the fatty acids and glycerin, of which they are composed, and usually develop a rancid odor and taste. When a fat is boiled with an alkali, it decomposes and the fatty acid unites with the alkali to form soap. If potash or lye is used, a soft soap is obtained; if soda is used, a hard soap is the result. Fatty oils are produced in many families of plants, both tropical and temperate. They are stored up, often in large amounts, in seeds (Fig. 89) and, to a less extent, in fruits, tubers, stems, and other plant organs; they are often associated with proteins. This type of reserve food material is available as a source of energy for the processes involved in the germination of the seed. The fatty oils are bland and lack the strong taste and odor and the antiseptic qualities of the essential oils. Consequently they are available as food for man. These edible oils contain both solid and liquid fats and form indispensable articles of human food. The demand for edible oils has so increased in recent years that various processes have been developed whereby the nonedible oils have been rendered available. This is usually done by hydrogenation, the adding of hydrogen. The method of extraction of the oils varies in different cases. Usually the seed coats have to be removed, and then the material is reduced to a fine meal. The oils are removed by solvents or by subjecting the meal to hydraulic pressure. This latter method is used for the edible oils. The residue is rich in proteins and is valuable as a fertilizer and as cattle feed. The pressure causes the cell walls to break and the fats escape. The extracted oils are filtered and may be further purified. The higher grades are edible, and the lower are used in the industries. The increasing demand for these industrial oils since the World War has led to the improvement of methods of cultivation and preparation, and also to a search for new sources the world over. Fatty oils also have a medicinal value.

Four classes of vegetable fatty oils are recognized: (1) drying oils, (2) semidrying oils, (3) nondrying oils, and (4) fats or fallows. The drying oils are able to absorb oxygen and on exposure dry into thin elastic films. These oils are of great importance in the paint and varnish industries. The semidrying oils absorb oxygen slowly and only in limited amounts. They form a soft film only after long exposure. Some of these oils are edible; others are used as illuminants or in making soap and candles. The nondrying oils remain liquid at ordinary temperatures and do not form a film. These oils are edible, and can be used for soap and lubricants. The fats are solid or semisolid at ordinary temperatures. They are edible and useful in the manufacture of soap and candles.

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13.6.1 SUNFLOWER OIL

The seeds of the common sunflower (*Helianthus annuus*), a native of Peru, contain an oil that is used for varnishes and soap and for edible purposes. The plant is cultivated for the oil in many parts of the world.

13.6.2 SOYBEAN OIL

The soybean (*Glycine Soja*), indigenous to Eastern Asia, and a food plant of paramount importance in that region, also yields a valuable oil, which is extracted from the seeds (Fig. 8) by expression or by treating ground seeds with some solvent. It is midway between linseed oil and cottonseed oil in its characteristics and so is sometimes classed as a drying oil and sometimes as a semidrying oil. After refining, soybean oil can be used as a salad oil and for other edible purposes. Inferior grades are used in the manufacture of candles, soap, varnish, printing ink, etc. Its industrial uses are constantly increasing in this country and in Europe become a crop of agriculture. In recent years soybeans have major importance in American.



Glycine Soja

13.6.3 SESAME OIL

This oil, known also as gingelly oil, is the product of the seeds of an annual herb, *Sesamum indicum*. It is the chief oil of India and has been cultivated there from remote times. Today over 3,000,000 acres are devoted to this crop. Its use has spread to other tropical regions and it is now grown in many Asiatic (Fig. 9) and African countries. Sesame oil was brought to the United States by the slaves, and the Southern Negroes grow the plant to this day. The seeds contain about 50 per cent oil, which

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is easily extracted by cold pressure. The finer grades are tasteless' and nearly colorless and are used as a substitute for olive oil in cooking and in medicine. European countries use enormous quantities, as it is a compulsory addition to margarine and other food products. Marseilles imports over 100,000,000 lb. The poorer grades are used for soap, perfumery, and rubber substitutes and to some extent as lubricants. In India the oil is used for anointing the body, as fuel for lamps, and as food. The oil cake is a good cattle food.



Sesamum indicum

13.6.4 PEANUT OIL

Peanuts the peanut (*Arachis hypogaea*) is a true legume rather than a nut, for the shuck is merely a shell-like pod. The plant is a bushy or creeping annual with the peculiar habit of ripening its fruit underground. The peanut is a native of Brazil but was early carried to the Old World tropics by the Portuguese explorers. It was brought to Virginia from Africa by the slaves and is now one of the most important crops of the South. In 1935, 1,702, - 435,000 lb. were grown, with Georgia the leading state. The commercial development has come about since the Civil War. As many as 20 kinds of peanuts are grown, differing in habit and the size of the pod. Peanuts require ample warm sunshine and a moderate rainfall. They can be grown successfully only south of 36°N.L. A sandy soil is best, although any but a low soil can be utilized. The soil must be friable so that the ripening fruit can be buried, and it must be well fertilized. In harvesting the crop, the rows are plowed and the plants are lifted out with forks, shocked, and capped to cure. Later the fruits are removed, cleaned, and polished. The plants may be used for forage, stock feeding, or as soil renovators. The nuts or seeds are used for roasting or salting, in candy, and for the preparation of peanut butter. For the latter purpose the seed coats and embryo are removed and the nuts are roasted either dry or in oil, and are then ground to a paste. Peanuts are a very nutritious food. One lb. yields 2700 cal., whereas 1 lb. of beef furnishes only 900 cal. Peanut oil, an important food oil, has been discuss below:

Peanut oil is obtained from the seed or "nut" of the common peanut (*Arachis hypogaea* Fig. 10), to be discussed later. The chief sources of the world's supply are the United States, West Indies, Africa, India, and China. The expression of the oil is carried out in Europe. The nuts are shelled, cleaned, crushed, and pressed. Cold-pressed oil has the best flavor and is nearly colorless. This is edible and is used as a salad

oil, for packing sardines, for margarine, and as an adulterant for olive oil. Inferior grades, expressed at higher temperatures, are used for soapmaking, lubricants, and illuminants. The cake is one of the best stock feeds as it has a higher percentage of vegetable fats.

Botanical Description

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Arachis hypogaea

13.6.5 COCONUT OIL

This is one of the most extensively used of the fatty oils. It is obtained from the dried meat of the coconut (*Cocos nucifera*). This oil is pale yellow or colorless and is solid below 74°F. After the nuts have been harvested, the husks are removed and the nuts split open and dried by either natural or artificial heat. The dried meat, or copra as it is called, is then easily removed. This is ground up and pressed by various methods. The cake is sometimes put through hydraulic presses and still more oil is removed. The yield is about 65 to 70 per cent. Recently, fresh meat has been utilized in the presses and this yields 80 per cent or more. The cold-pressed oil is edible and is now much used for food products, chiefly margarines. It is particularly well adapted for this purpose as it is solid at ordinary temperatures; many artificial butters prepared from it are now on the market. Coconut oil has long been used for the best soaps, cosmetics, salves, shaving creams, shampoos, and other toilet preparations. It is also useful as an illuminant. The cake is an excellent stock food. About 500,000 tons of C nuts are used annually for the oil. Copra is produced chiefly in the Straits Settlements, Ceylon, India, Polynesia, the Philippine Islands, and the West Indies. Most of the oil is expressed in Europe, the United States, and Japan, although Ceylon and India export large amounts.



Cocos nucifera

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13.6.6 PALM OIL

Palm oil is a white vegetable fat, solid at ordinary temperatures, it is obtained from the nuts of the oil palm content than any other oil tree. (*Elaeis guineensis*). This tree is a native of Western Africa but has spread all through the tropics and now covers enormous areas. It is frequently cultivated. The oil palm is a very productive tree. It begins to bear at the age of 5 to 6 years, reaches full bearing at 15, and continues until 60 or 70 years of age. Each tree bears 10 bunches of 200 nuts a year. The fibrous pulp of these fruits contains 55 to 60 per cent of fat. The oil is obtained chiefly by crude native methods. It is yellow-orange or brownish red in color, and, although eaten by the natives, it is used chiefly in the soap and candle industries. Over 200,000 tons of the oil enter the world trade, coming from Sumatra, Java, and the west coast of Africa. The kernels of the oil palm yield different oil, which is white in color and more valuable. Palm-kernel oil is used in the margarine industry for it has a pleasant odor and nutty flavor. It is also used for soap and candles. The natives express a little oil for their own use, but the kernels are usually shipped to the oil mills of Europe and the United States where the oil is extracted by hydraulic presses or by solvents. Over 500,000 tons of the kernels are used. Palm-kernel cake is a good food for cattle.



Elaeis guineensis

13.7 FIBERS AND TIMBERS

Plants that yield fibers have without question been second only to food plants in their usefulness to man and their influence on the advancement of civilization. Primitive man in his attempt to obtain the three great necessities of life—food, shelter, and clothing—early turned to plants. Although animal products were available, he needed some form of clothing that was lighter and cooler than skins and hides. For his snares, bowstrings, nets, and the like he needed some form of cordage that was easier to procure than animal sinews and strips of hide. Moreover, some other type of covering for his crude shelters was desirable. All these needs were admirably met by the tough, flexible strands that occurred in the stems, leaves, and roots of many plants. Almost from the outset plant fibers have had a more extensive use than wool, silk, and other animal fibers. As civilization advanced and man's needs multiplied, the use of these vegetable fibers increased greatly until

at the present time they are of enormous importance in our daily life. It is difficult to estimate the number of species of fiber plants, but a conservative figure would be well over a thousand. Seven hundred and fifty occur in the Philippine Islands alone. Fibers of commercial importance are relatively few, the greater number comprising native species used locally by primitive peoples in all parts of the world. It is a remarkable fact that the most prominent fibers of the present day are of great antiquity. The cultivation of flax, for example, goes back to the Stone Age of Europe, as evidenced by the remains of the Swiss Lake Dwellers. Ancient Egypt was famous for its fine linen. Cotton was the ancient national textile of India, and was used by all the aboriginal nations of the New World as well. Ramie or China grass has been grown in the Orient from time immemorial.

Economic classification of fibers

It is possible to classify fibers in six groups, based on their utilization, as follows:

Structure occurrence of Fibers, Although put to so many different uses, and perhaps differing in texture, strength, chemical composition, and place of origin, with few exceptions fibers are alike in that they are sclerenchyma cells and serve as part of the plant skeleton. For the most part they are long cells with thick walls, correspondingly small cavities, and usually pointed ends. The walls often contain lignin as well as cellulose. Fibers may occur singly or in small groups, but they are more likely to form sheets of tissue with the individual cells overlapping and interlocking. Fibers may be found in almost any part of the plant—stems, leaves, roots, fruits, and even seeds. The four chief types, classified according to their origin, include bast fibers; wood fibers; sclerenchyma cells associated with the vascular-bundle strands in leaves; and surface fibers, which are hairlike outgrowths on the seeds of various plants. The use of the term "bast fiber" is open to criticism on the ground that it gives no indication as to the particular tissue or region in which the fibers occur.

13.7.1 Cotton

Cotton is the world's greatest industrial crop, the chief fiber plant, and one of the oldest as well as the cheapest. It was known to the ancient world long before written records were made. References to it are to be found in the works of the Greek and Roman writers. Cotton has been in use in India since 1800 B.C., and from 1500 B.C. to 1500 A.D. that country was the center of the industry. The Hindus were the first people to weave cloth. Cotton was introduced into Europe by the Mohammedans, and the word it has is derived from the Arabic "qutn." Apparently the plant had several origins for Columbus found it in cultivation in the West Indies, and it was known to the Peruvians and Mexicans long before the days of the Spanish conquerors. Cotton was first grown in the United States soon after the first settlements were made. The first cotton mill, however, did not commence operations until 1787.

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Production of Cotton-In 1935-1936 the world produced an estimated total of 26,000,000 bales of cotton, a bale comprising 500 lb. gross weight. The United States led in production with 10,635,000 bales, followed by India with 4,793,000, China with 2,500,000, Russia with 2,250,000, Egypt with 1,750,000, and Brazil with 1,743,000 bales. Brazil has had a spectacular rise as a cotton-producing country during the last few years, the output increasing from 455,000 bales in 1932-1933 to 1,743,000 bales in 1935-1936. For many years prior to 1934 the United States produced at least one-half of the world's output of cotton. Since that time normal cotton production has been curtailed as a result of governmental regulations. However, an average of about 37,000,000 acres of cotton has been grown in the United States during the last 25 years, nearly one-third of which was from a morphological viewpoint it would be preferable to designate those fibers which occur in the outer parts of a stem as cortical fibers, pericyclic fibers, or phloem fibers. However, "bast" is a term of such long standing and so firmly established in commerce that it will be used in the present discussion. Fibers of economic importance are furnished by many different families of plants, particularly those which occur in the tropics. Among the more important may be mentioned the Gramineae, Palmaceae, Musaceae, Liliaceae, Amaryllidaceae, Urticaceae, Moraceae, Linaceae, Bombacaceae, Leguminosae, Myricaceae, Tiliaceae, and Bromeliaceae. Texas. The United States, India, Egypt, and Brazil are the chief exporting countries, while Great Britain, Japan, and Germany lead in the importation of cotton.

Characteristics of Cotton-Cotton is obtained from several species of the genus *Gossypium*. The fine fibrous hairs that occur on the seeds constitute the raw material of the industry. These hairs, which are flattened, twisted, and tubular, compose the lint, floss, or staple, the length and other qualities of which vary in different varieties. The cotton plant is naturally a perennial shrub or small tree, but under cultivation it is treated as an annual. It branches freely and grows to a height of 4 to 8 ft. Cotton thrives best in that are near water. This type of environment is especially characteristic of the southern United States and the river valleys of India and Egypt. Cotton matures in five or six months and is ready for picking soon after ripening.

Kinds of Cotton-The hundreds of varieties of cultivated cotton have been developed from wild ancestors or produced by breeding during the long period of cultivation. These varieties differ in fiber character as well as other morphological and cultural features. Cotton is a very difficult group to classify, and few authorities agree as to the exact number of species. In the United States, however, the various types are usually referred to one or the other of two species.

1. *Gossypium barbadense*-The native home of this species is in doubt, but it was probably derived from a Central American plant. In this cotton the flowers are bright yellow with purple spots. The fruit, or boll

as it is called, has three valves, and the seeds are fuzzy only at the ends. Two distinct types of cotton belong here:

Sea-Island cotton

This type of cotton has never been found growing wild as it was already in cultivation at the time of Columbus. Its light cream-colored fibers are more regular in the number and uniformity of the twists and have a silkier appearance than those of other cottons. These features are exceedingly valuable and sea-island cotton was formerly in great demand for the finest textiles, yarns, and spool cotton, and also for mercerizing. Sea-island cotton was brought to the United States: from the West Indies in 1785. The finest types were developed on the islands off the South Carolina coast and the adjacent mainland. Here staples 2 in. or more in length, surpassing all the others in strength and firmness, were produced. Another form of sea-island cotton was grown along the coast in Georgia and Florida, and is still cultivated in the West Indies and South America. This has a staple from 1 1/2 to 1 3/4 in. in length. The maximum yield of sea-island cotton was only 100,000 bales, but this was compensated for by the greater value of the fiber. In recent years the growing of sea-island cotton has almost entirely ceased owing to the ravages of the boll weevil.

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Egyptian cotton

Egyptian cotton is grown chiefly in the Nile basin of Egypt, where it was introduced from Central America. By some authorities it is considered to be a derivative of *Gossypium peruvianum*, rather than of *G. barbadense*. The plant is quite similar in appearance to sea-island cotton. The staple, however, is brown in color and somewhat shorter, measuring from 1 1/2 to 1 3/4 in. in length. Because of its length, strength, and firmness this cotton is used for thread, underwear, hosiery, tire fabrics, and fine dress goods. Egyptian cotton was brought to the United States in 1902 as an experimental crop, and 10 years later it was recommended to farmers in the semiarid regions that are irrigated. A considerable quantity is now grown in California and Arizona. Repeated selection and breeding have resulted in the development of new and better strains, of which Pima is one of the best. A large amount of Egyptian cotton is still imported, amounting at times to one-tenth of Egypt's entire crop.

2. *Gossypium hirsutum* - This is a Native American species long grown by the Incas and Aztecs. It is commonly called upland cotton (Fig. 8). The flowers are white or light yellow and unspotted. The bolls are four- or five-lobed, and the seeds are fuzzy all over. Upland cotton grows well under a variety of conditions, but prefers a sandy soil with plenty of moisture during the growing and fruiting season and dryness during the time of boll opening and harvest, together with a temperature range of 60 to 90°F. The northern limit of economic growth is 37°N.L. The great Cotton Belt of the southern United States grows upland cotton almost entirely and produces two-thirds of the world's output of this type of cotton. In general two main types of upland cotton are recognized.

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These are the long-staple, with fibers 17-8 to 172 in. in length; and the short-staple, with fibers $\frac{1}{2}$ to 1 in. long. In both cases the fibers are white. There are over 1200 named varieties of upland cotton, many of which have been developed as a result of breeding experiments. Upland cotton is the easiest and cheapest kind to grow and constitutes 99 per cent of the domestic crop of cotton.

3. *Gossypium herbaceum*-This third species of cotton is not found in America, but is the chief cotton of Asia. It has been and soil in damp, humid regions Fceaegrown in India from time immemorial and is also extensively cultivated for home consumption in Persia, China, Japan, and elsewhere. The staple of Asiatic cotton is short, only $\frac{1}{2}$ to $\frac{3}{4}$ in. in length, but it is strong. In addition to these cultivated species several wild species of *Gossypium* are still to be found in some tropical and subtropical countries. The Cotton Industry.-For a long time cotton was a very expensive product for it was difficult to remove the fibers from the seed. The invention of the cotton gin by Eli Whitney in 1793, however, remedied this situation and was responsible for revolutionizing the industry, which rapidly assumed proportions of first importance in both America and England. Cotton today is probably the most important article in the commerce of the world. The economics of this single crop has a profound effect on both the producing and the consuming nations. The steady decrease in the value of the cotton crop in the United States, due to adverse world conditions, has had such a serious effect on the life of the Cotton Belt farmers that government control has been resorted to in recent years in an attempt to improve the situation. Several operations are necessary in order to prepare the raw cotton fiber, as it comes from the field, for use in the textile industry. In brief these operations are as follows: ginning in either a saw-tooth or a roller gin; baling; transporting to the mills; picking, a process in which a machine removes any foreign matter and delivers the cotton in a uniform layer; lapping, an operation whereby three layers are combined into one; carding, combing, and drawing, during which the short fibers are extracted and the others are straightened and evenly distributed; and finally twisting the fibers into thread.

The Uses of Cotton-The chief use of cotton, either alone or in combination with other fibers, is in the manufacture of textiles of all types, which are too numerous to mention. It is an important constituent of rubber-tire fabrics, and unspun cotton is extensively used for stuffing purposes. Absorbent cotton, consists of fibers which have been thoroughly cleaned and from which the oily covering layer has been removed. It is almost pure cellulose and constitutes one of the basic raw materials of the various cellulose industries to be discussed later. One of the most noteworthy advances in the cotton industry has been the utilization of what were formerly treated as waste products. At one time the cotton seed, together with its fuzzy covering of short hairs, or linters, was discarded as valueless. Today, however, all parts of the plant are

conserved and yield products that are worth several million dollars annually. The stalks contain a fiber that can be used in paper making or for fuel, and the roots possess a crude drug. The seeds are of the greatest importance and every portion is utilized. The linters furnish wadding; stuffing for pads, cushions, pillows, mattresses, etc.; absorbent cotton; low-grade yarn for twine, ropes, and carpets; and cellulose. The hulls are used for stock feed; as fertilizer; for lining oil wells to prevent the caving in of the sides; as a source of xylose, a sugar that can be converted into alcohol, or various explosives and industrial solvents; and for many other purposes. The kernels yield one of the most important fatty oils, cottonseed oil, which will be discussed later, and an oil cake and meal which are used for fertilizer, stock feed, flour, and as a dyestuff.

Hemp There is often considerable confusion as to the real identity of a given commercial hemp fiber, because the term "hemp" is applied rather loosely to include quite a number of very different plants and fibers. The true hemp is *Cannabis sativa*. This plant is a native of Central and Western Asia, but it is extensively cultivated at the present time in both temperate and tropical regions. It often occurs as a troublesome weed. The hemp plant is a stout, bushy, branching annual arising from 5 to 15 ft. in height. It is a dioecious species with hollow stems and palmate leaves. The best grade of fiber is obtained from the male plants. For its best development hemp requires a mild humid climate and a rich loamy soil with an abundance of humus. Calcareous soils are particularly well adapted to hemp culture. Hemp fiber is a white bast fiber which develops in the pericycle. It is valuable because of its length, which varies from 3 its strength, and great durability. It lacks, however, the flexibility and elasticity of flax, because it is somewhat lignified. The yield of hemp is large, an acre producing 2 or 3 tons of stems, 25 per cent of which is fibrous material. The plants are harvested by hand or machine and are shocked and dried. The fibers are separated from the rest of the bark by letting, either in dew or in water. They are then broken, scutched, and hackled by hand. Hemp must be harvested when the male flowers are fully out; otherwise the fibers are too weak or too brittle to be of value. Hemp is a very old crop and has been grown in China for centuries. It was introduced into Europe about 1500 B.C., and that continent is the center of the industry today. Hemp has been grown in the United States since 1775 and at one time constituted a considerable industry in Kentucky. At the present time Wisconsin leads in production. It is an expensive crop, however, and in most regions has been gradually replaced by other coarse fibers.

Hemp is used for ropes, twine, carpets, sailcloth, yacht cordage, binder twine, sacks, bags, and webbing. Hemp waste and the woody fibers of the stem are sometimes used in making paper. The finer grades of hemp can be woven into a cloth that looks like coarse linen. The short fibers, or tow, and ravelings constitute oakum. This is used for caulking the seams between the planks used in shipbuilding; in cooperage; and as

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a packing for pumps, engines, etc. In tropical regions hemp is grown for its seed, and also for a drug that is obtained from the flowering tops and leaves. The seeds contain an oil that is useful in the soap and paint industries as a substitute for linseed oil. The drug, known as hashish, is a resinous substance that contains several powerful alkaloids. Its use and the important part it has played in the economic and social life of many countries will be discussed later. Jute is probably used more extensively than any other fiber except cotton, although it is much less valuable than either cotton or flax. Jute is a bast fiber obtained from the secondary phloem of two species of *Corchorus*, an Asiatic genus. The best fiber comes from *Corchorus capsularis*, which is grown in upland areas, but that from *C. olitorius*, a lowland species, is but little inferior, and the two are not differentiated for commercial purposes. Although probably a native of Malaya or Ceylon, jute is now almost entirely an Indian crop. Several million acres are cultivated in the valleys of the Ganges and Brahmaputra, rivers. Jute is a tall, slender, half-shrubby annual with yellow flowers. It grows to a height of 8 to 12 ft. It requires a warm humid climate and a rich, loamy, alluvial soil, which is frequently inundated. The crop is harvested within three or four months after planting, while the flowers are still in bloom. The stems are retted in pools or tanks for a few days to rot out the softer tissues, and the jute, or gunny, strands are then loosened by whipping the stems on the surface of the water. The very long fibers are quite stiff, as they are considerably lignified; they have a silky luster. They are very abundant, but are not particularly strong and tend to deteriorate rapidly when exposed to moisture, to which they are exceedingly susceptible. In spite of these disadvantages, the fact that jute is cheap and easily spun makes it to 9 ft. its strength, and great durability. It lacks, however, the flexibility and elasticity of flax, because it is somewhat lignified. The yield of hemp is large, an acre producing 2 or 3 tons of stems, 25 per cent of which is fibrous material. The plants are harvested by hand or machine and are shocked and dried. The fibers are separated from the rest of the bark by retting, either in dew or in water. They are then broken, scutched, and hackled by hand. Hemp must be harvested when the male flowers are fully out; otherwise the fibers are too weak or too brittle to be of value. Hemp is a very old crop and has been grown in China for centuries. It was introduced into Europe about 1500 B.C., and that continent is the center of the industry today. Hemp has been grown in the United States since 1775 and at one time constituted a considerable industry in Kentucky. At the present time Wisconsin leads in production. It is an expensive crop, however, and in most regions has been gradually replaced by other coarse fibers. Hemp is used for ropes, twine, carpets, sailcloth, yacht cordage, binder twine, sacks, bags, and webbing.

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tute oakum. This is used for caulking the seams between the planks used in shipbuilding; in cooperage; and as a packing for pumps, engines, etc. In tropical regions hemp is grown for its seed, and also for a drug that is obtained from the flowering tops and leaves. The seeds contain an oil that is useful in the soap and paint industries as a substitute for linseed oil. The drug, known as hashish, is a resinous substance that contains several powerful alkaloids. Its use and the important part it has played in the economic and social life of many countries will be discussed later. Jute Jute is probably used more extensively than any other fiber except cotton, although it is much less valuable than either cotton or flax. Jute is a bast fiber obtained from the secondary phloem of two species of *Corchorus*, an Asiatic genus. The best fiber comes from *Corchorus capsularis*, which is grown in upland areas, but that from *C. olitorius*, a lowland species, is but little inferior, and the two are not differentiated for commercial purposes. Although probably a native of Malaya or Ceylon, jute is now almost entirely an Indian crop. Several million acres are cultivated in the valleys of the Ganges and Brahmaputra, rivers. Jute is a tall, slender, half-shrubby annual (Fig. 11) with yellow flowers. It grows to a height of 8 to 12 ft. It requires a warm humid climate and a rich, loamy, alluvial soil, which is frequently inundated. The crop is harvested within three or four months after planting, while the flowers are still in bloom. The stems are retted in pools or tanks for a few days to rot out the softer tissues, and the jute, or gunny, strands are then loosened by whipping the stems on the surface of the water. The very long fibers are quite stiff, as they are considerably lignified; they have a silky luster. They are very abundant, but are not particularly strong and tend to deteriorate rapidly when exposed to moisture, to which they are exceedingly susceptible. In spite of these disadvantages, the fact that jute is cheap and easily spun makes it valuable. Practically every civilized country imports some form of Bengal gunny, as it is often called. Jute is used chiefly for rough weaving, and the familiar burlap bags, gunny, wool, and potato sacks, and the covers for cotton bales, are made from it. The fiber is also used for making twine, carpets, curtains, and coarse cloth. Short fibers and pieces from the lower ends of the stalks constitute jute butts, which are used to some extent in paper making.

13.7.2 SUN HEMP

Sunhemp, or san hemp (*Crotalaria juncea*) is an important Asiatic fiber plant. It is not known in the wild state for it has been cultivated for centuries. In fact, it is the earliest fiber to be mentioned in Sanskrit writings. The plant is a shrubby annual from 6 to 10 ft. in height, with bright yellow flowers. It is extensively grown in India where over 500,000 acres are planted every rainy season, chiefly in the region around Madras. Sunn hemp is also cultivated in Ceylon and elsewhere in the Orient. The bast yields a fiber that is stronger than jute, lighter in color, and more enduring. It is used for cordage, sacks, nets, and coarse

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canvas. The United States imports a considerable quantity for coarse twines.

13.7.3 TEAK

Teak (*Tectona grandis*) is one of the most durable of woods and one of the most important commercial timbers of the tropics. It is hard and does not warp, split, or crack, and so makes a valuable timber for general construction. The wood is yellowish brown in color and greasy to the touch. It is extensively used in ship and boat building, and for furniture, millwork, piles, railway cars, flooring, and greenhouses. Other important woods of tropical Asia include the ake or pinkado (*Xylia xylocarpa*), sal (*Shorea robusta*), and sissoo (*Dalbergia Sissoo*), all used for general construction, and the following cabinet woods: Moulmein cedar (*Cedrela Toona*), laurelwood (*Calophyllum inopinatum*), yllum, rosewood (*Dalbergia latifolia*), and sandalwood (*Santalum album*).

13.7.4 FATTY OILS

Another type of oil that occurs in plants is the fatty oil. The fatty oils are also called fixed oils because, unlike the essential oils, they do not evaporate or become volatile, and they cannot be distilled without being decomposed. Chemically these vegetable fatty oils are close to animal fats. They consist of glycerin in combination with a fatty acid. The so-called oils are liquid at ordinary temperatures and usually contain oleic acid. The fats, on the other hand, are solid at ordinary temperatures and contain stearic or palmitic acid. The fatty oils are insoluble in water, but soluble in various organic solvents. When fats break down, they yield the fatty acids and glycerin, of which they are composed, and usually develop a rancid odor and taste. When a fat is boiled with an alkali, it decomposes and the fatty acid unites with the alkali to form soap. If potash or lye is used, a soft soap is obtained; if soda is used, a hard soap is the result. Fatty oils are produced in many families of plants, both tropical and temperate. They are stored up, often in large amounts, in seeds and, to a less extent, in fruits, tubers, stems, and other plant organs; they are often associated with proteins. This type of reserve food material is available as a source of energy for the processes involved in the germination of the seed. The fatty oils are bland and lack the strong taste and odor and the antiseptic qualities of the essential oils. Consequently they are available as food for man. These edible oils contain both solid and liquid fats and form indispensable articles of human food. The demand for edible oils has so increased in recent years that various processes have been developed whereby the nonedible oils have been rendered available. This is usually done by hydrogenation, the adding of hydrogen. The method of extraction of the oils varies in different cases. Usually the seed coats have to be removed, and then the material is reduced to a fine meal. The oils are removed by solvents or by subjecting the meal to hydraulic pressure. This latter method is used for the edible oils. The residue is rich in proteins and is valuable as a fertilizer and as a

cattle feed. The pressure causes the cell walls to break and the fats escape.

Check your Progress

1. State the botanical names, families and morphology of the parts from which the following are obtained
a).Cotton b). Jute c) Sun Hemp
2. Give the method of extraction, properties and economic uses of following
a)Palm oil b) Gingerly oil c) Coconut oil
3. List the chief fatty oil yielding crops in India.
4. Give botanical names of three important timber yielding plants of India
5. Name any two economic uses of cotton other than using it in textile industry

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13.7.5 ROSEWOOD: *Dalbergia sissoo* Roxb. **Family:** Papilionaceae.

Shisham is the best known economic timber species of the rosewood genus sold internationally, but it is also used as fuel wood and for shade and shelter. After teak, it is the most important cultivated timber tree of Bihar, which is the largest producer of shisham timber in India. In Bihar, the tree is planted on roadsides, along canals and as a shade tree for tea plantations. It is also commonly planted in southern Indian cities like Bangalore as a street tree.

Sheesham is usually dried before being used in furniture manufacturing, a process commonly known as seasoning. Locally sheesham is left in wide open areas to dry under the sun for about six months. Commercially, sheesham is dried in closed chambers with hot air circulation for about seven to fifteen days, depending on weather conditions. The ideal moisture level is supposed to be 5-6% for thinner pieces and up to 11% for thicker ones, depending on use. Anything lower than this can cause sudden cracking of the final products.

Sheesham is among the finest cabinet and veneer timbers. It is the wood from which 'mridanga', the Rajasthani percussion instrument, is often made. In addition to musical instruments, it is used for plywood, agricultural tools, flooring, and as a bentwood, and for turning.

The heartwood is golden to dark brown; the sapwood is white to pale brownish white. The heartwood is durable (the specific gravity is 0.7 – 0.8) and is very resistant to fungi; but the sapwood is readily attacked by dry-wood termites and borers. *Dalbergia sissoo* is known to contain the neoflavonoid dalbergichromene in its stem-bark and heartwood

13.7.6 EBONY: *Diospyros ebenum*, Family: Ebenaceae

Ebony is a dense black/brown hardwood, most commonly yielded by several different species in the genus *Diospyros*, which also contains

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the persimmons. Ebony is dense enough to sink in water. It is finely-textured and has a very smooth finish when polished, making it valuable as an ornamental wood. Ebony has a long history of use, with carved pieces having been found in Ancient Egyptian tombs.

Ebony has a long history of use, with carved pieces having been found in Ancient Egyptian tombs.

By the end of the 16th century, fine cabinets for the luxury trade were made of ebony in Antwerp. The wood's dense hardness lent itself to refined moldings framing finely detailed pictorial panels with carving in very low relief (bas-relief), usually of allegorical subjects, or with scenes taken from classical or Christian history. Within a short time, such cabinets were also being made in Paris, where their makers became known as *ébénistes*, which remains the French term for a cabinetmaker.

Modern uses are largely restricted to small items, such as crucifixes, and musical instrument parts, including black piano and harpsichord keys, violin, viola, mandolin, guitar, double bass, and cello fingerboards, tailpieces, pegs, chinrests, and bow frogs. Many plectra, or guitar picks, are made from this black wood.

Traditionally, the black pieces in chess sets were made from ebony, with rare boxwood or ivory being used for the white pieces. Modern East Midlands-style lace-making bobbins, also being small, are often made of ebony and look particularly decorative when bound with brass or silver wire. Due to its strength, many handgun grips and rifle fore-end tips are made of ebony, as are the butts of pool cues.

As a result of unsustainable harvesting, many species yielding ebony are now considered threatened. Africa in particular has had most of its indigenous ebony cut down illegally.

13.7.7 SAL: *Shorea robusta*, the sal tree is a species of tree in the family Dipterocarpaceae. Sal is an evergreen tree with an elongated crown when young, becoming more rounded as the tree ages. It can grow up to 50 metres tall in fertile soils, but is more likely to be 20 - 25 metres tall in poorer soils. The straight, cylindrical bole can be unbranched for up to 25 metres and up to 200cm in diameter. Sal is a very important multi-purpose tree. It is one of the main commercial timbers of India, being harvested from the wild for local use and export. It also yields a resin that is traded and an oil that is used locally as well as being exported in large quantities. In addition, it supplies tannins, an edible seed and medicines for local use. The leaves are used commercially for making plates and containers.

The sal tree is often the dominant species in the forests of the sub-Himalayan tract, but overutilization of it for fuel, timber, fodder etc is becoming a cause for conservation concern in some areas. It is classified as being of 'Least Concern' in the IUCN Red List of Threatened Species (2010).

Seed – roasted. The seeds are boiled into porridge with the flowers of *Bassia latifolia* and the fruits of *Dolichos biflorus*. They can be ground

into a coarse flour that is used to make bread, and the plant is used as a famine food. A de-fatted kernel powder, popularly known as sal seed cake, contains about 50% starch, in addition to proteins, tannins and minerals. The physico-chemical property of the starch can be exploited for preparing canned food products. The chemical composition of the seeds consists of 10.8% water, 8% protein, 62.7% carbohydrate, 14.8% oil, 1.4% fibre and 2.3% ash. The seeds are a source of 'sal butter, an oil that is used in cooking like ghee and as a substitute for cocoa butter in making chocolate. Fruit - occasionally eaten.

Medicinal uses: The resin is valued for its use in the treatment of dysentery, gonorrhoea, boils and toothaches. The leaf juice is used in the treatment of dysentery. The leaves are warmed and used as a poultice on areas of the body that are swollen. They have a quick effect. They are also applied to the stomach of children with dysentery. The oil from the seed is used to treat skin diseases.

13.7.8 MAHOGANY: Indian Mahogany grow up to the height of 30 -40 feet. It is fast upright growing tree with abroad rounded symmetrical crown. It is 20 -30 feet in spread. The fruit is a large greenish brown capsule, splitting into 5 parts releasing flat, long winged, light brown seeds. Its wood is red brown in colour. Both the male and the female flowers are produced on the same plant. The bark is smooth dark brown in colour. The leaves are pinnate which are 12 -25 cm long, with four to eight leaflets.

Indian Mahogany is found in almost all the parts of India. It can also be found in Thattekkad Wildlife Sanctuary, Kaziranga National Park and Corbett National Park in India. Indian Mahogany is mostly propagated through seeds. It requires partial shade or full Sun for its growth. It needs water periodically. It loses its leaves at the end of the winter. The new leaves start growing after two three weeks. The new leaves are reddish purple in colour, which turn yellow green afterwards.

The bark extracts are used as an astringent for wounds. It is used to cure malaria, anemia diarrhea, fever, dysentery and depurative. The leaves contain several limonoids; seven phragmalin limonoids of swietephragmins A-G as well two other different types of 2-hydroxy-3-O-tigloylswietenolide and deacetylsecomahoganin. Its wood is used in making furniture, fixtures, musical instruments, inlay, boat, caskets and many more. Its wood is a very popular material for drum making.

13.8 LET US SUM UP

In this unit you have learnt about the general account on vegetative oils, fibres and timbers and their uses. This unit clearly described important oils which we have used our day today life such as Sun flower, Soya bean, Sesame oil, Peanut oil, Coconut oil and Palm Oil. Also you have learnt botanical description, timbers and medicinal values of important timbers and fibres.

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13.9 UNIT END EXERCISES

- Origin and history and cultivation of vegetable oils.
- Botanical description, harvesting, medicinal values and economic importance of vegetable oils, timbers and fibres.

13.10 ANSWER TO CHECK YOUR PROGRESS

1. A) Cotton. Botanical name- **Gossypium barbadense**
families- Malvaceae and morphology of the part – fibres)
 - B). Jute: Botanical name *Corchorus capsularis*, families - Tiliaceae and morphology of the parts- fibre
 - C) Sunhemp: botanical name – *Crotolaria juncea* families - Fabaceae morphology of the parts - fibre
2. A. PALM- The oil is obtained chiefly by crude native methods.
It is yellow-orange or brownish red in color, and, although eaten by the natives, it is used chiefly in the soap and candle industries. Over 200,000 tons of the oil enter the world trade, coming from Sumatra, Java, and the west coast of Africa. The kernels of the oil palm yield different oil, which is white in color and more valuable. Palm-kernel oil is used in the margarine industry for it has a pleasant odor and nutty flavor. It is also used for soap and candles. The natives express a little oil for their own use, but the kernels are usually shipped to the oil mills of Europe and the United States where the oil is extracted by hydraulic presses or by solvents. Over 500,000 tons of the kernels are used. Palm-kernel cake is a good food for cattle.
- B. Gingelly Oil** -The seeds contain about 50 per cent oil, which is easily extracted by cold pressure. The finer grades are tasteless' and nearly colorless and are used as a substitute for olive oil in cooking and in medicine. The poorer grades are used for soap, perfumery, and rubber substitutes and to some extent as lubricants. In India the oil is used for anointing the body, as fuel for lamps, and as food. The oil cake is a good cattle food. A large variety of oil seeds are produced in India such as groundnut, castor seed, sesame, rapeseed and mustard, linseed, Soybean, sunflower, nigersee. Moulmein cedar (*Cedrela Toona*), laurelwood (*Calophyllum inop*), rosewood (*Dalbergia latifolia*) and sandalwood (*Santalum album*). All parts of the plant are conserved and yield products that are worth several million dollars annually. The stalks contain a fiber that can be used in paper making or for fuel, and the roots possess a crude drug. The hulls are used for stock feed; as fertilizer.
- C. Coconut Oil**
This is one of the most extensively used of the fatty oil. It is obtained from the dried meat of the coconut (*Cocos nucifera*). This oil is pale yellow or colorless and is solid below 74°F. After the nuts have been harvested, the husks are removed and the nuts split open and dried by

either natural or artificial heat. The dried meat, or copra as it is called, is then easily removed. This is ground up and pressed by various methods. The cake is sometimes put through hydraulic presses and still more oil is removed. The yield is about 65 to 70 per cent. Recently, fresh meat has been utilized in the presses and this yields 80 per cent or more. The cold-pressed oil is edible and is now much used for food products, chiefly margarine. Many artificial butters prepared from it are now on the market. Coconut oil has long been used for the best soaps, cosmetics, salves, shaving creams, shampoos, and other toilet preparations. It is also useful as an illuminant. The cake is an excellent stock food.

3. Uses of cotton: The chief use of cotton, either alone or in combination with other fibers, is in the manufacture of textiles of all types, which are too numerous to mention. It is an important constituent of rubber-tire fabrics, and unspun cotton is extensively used for stuffing purposes. Absorbent cotton, consists of fibers which have been thoroughly cleaned and from which the oily covering layer has been removed. It is almost pure cellulose and constitutes one of the basic raw materials of the various cellulose industries to be discussed later. One of the most noteworthy advances in the cotton industry has been the utilization of what were formerly treated as waste products.

13.11 SUGGESTED READINGS

1. Frank D. Gunstone, 2011, Vegetable Oils in Food Technology: Composition, Properties and Uses, Blackwell Publishing Ltd. USA, ISBN:9781444332681.
2. H. E. Desch. J. M. Dinwoodie, 1996, Timber Structure, Properties, Conversion and Use, Macmillan Press, London, ISBN 978-0-333-60905-7

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UNIT- 14. ETHNOBOTANY

NOTES

Structure

- 14.1 Introduction
- 14.2 Objectives
- 14.3 Ethno botany
- 14.4 Origin and History,
- 14.5 Botanical description,
- 14.6 Cultivation,
- 14.7 Processing and Uses of - Medicinal Plants:
 - 14.7.1 Rauwolfia,
 - 14.7.2 Aconitum,
 - 14.7.3 Jatamansi,
 - 14.7.4 Sathavari,
 - 14.7.5 Goggul,
 - 14.7.6 Basil,
 - 14.7.7 Saraca
 - 14.7.8 Neem.
- 14.8 Let us sum up
- 14.9 Unit end Exercises
- 14.10 Answer to check your progress
- 14.11 Suggested readings

14.1 INTRODUCTION

The term "ethnobotany" was first used by a botanist named John W. Harshberger in 1895 while he was teaching at the University of Pennsylvania. Although the term was not used until 1895, practical interests in ethnobotany go back to the beginning of civilization when people relied on plants as a way of survival.

Ethnobotany (from "ethnology" - study of culture and "botany" - study of plants) is the scientific study of the relationships that exist between people and plants.

Ethnobotanists aim to reliably document, describe and explain complex relationships between cultures and (uses of) plants: focusing, primarily, on how plants are used, managed and perceived across human societies (eg. as foods; as medicines; in divination; in cosmetics; in dyeing; as textiles; in construction; as tools; as currency; as clothing; in literature; in rituals; and in social life.)

14.2 OBJECTIVES

- To study about Ethnobotany -Origin and History,

- To learnt about Botanical description, Cultivation, Processing and uses of - Medicinal Plants: Rauvolfia, Aconitum, Jatamansi, Sathavari, Goggul, Basil, Saraca and Neem.

14.3 ETHNO BOTANY

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Ethnobotany -Origin and History

Though the term "ethnobotany" was not coined until 1895 by the US botanist John William Harshberger, the history of the field begins long before that. In AD 77, the Greek surgeon Dioscorides published "De Materia Medica", which was a catalog of about 600 plants in the Mediterranean. It also included information on how the Greeks used the plants, especially for medicinal purposes. This illustrated herbal contained information on how and when each plant was gathered, whether or not it was poisonous, its actual use, and whether or not it was edible (it even provided recipes). Dioscorides stressed the economic potential of plants. For generations, scholars learned from this herbal, but did not actually venture into the field until after the middle Ages.

In 1542 Leonhart Fuchs, a Renaissance artist, led the way back into the field. His "De Historia Stirpium" cataloged 400 plants native to Germany and Austria.

John Ray (1686-1704) provided the first definition of "species" in his "Historia Plantarum": a species is a set of individuals who give rise through reproduction to new individuals similar to themselves.

In 1753 Carl Linnaeus wrote "Species Plantarum", which included information on about 5,900 plants. Linnaeus is famous for inventing the binomial method of nomenclature, in which all species get a two part name (genus, species).

The 19th century saw the peak of botanical exploration. Alexander von Humboldt collected data from the new world, and the James Cook's voyages brought back collections and information on plants from the South Pacific. At this time major botanical gardens were started, for instance the Royal Botanic Gardens, Kew.

Edward Palmer collected artifacts and botanical specimens from peoples in the North American West (Great Basin) and Mexico from the 1860s to the 1890s.

Once enough data existed, the field of "aboriginal botany" was founded. Aboriginal botany is the study of all forms of the vegetable world which aboriginal peoples use for food, medicine, textiles, ornaments, etc.

The first individual to study the emic perspective of the plant world was a German physician working in Sarajevo at the end of 19th Century: Leopold Glueck. His published work on traditional medical uses of plants done by rural people in Bosnia (1896) has to be considered the first modern ethnobotanical work.

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The term "ethnobotany" was first used by a botanist named John W. Harshberger in 1895 while he was teaching at the University of Pennsylvania. Although the term was not used until 1895, practical interests in ethnobotany go back to the beginning of civilization when people relied on plants as a way of survival. Other scholars analysed uses of plants under an indigenous/local perspective in the 20th century: e.g. Matilda Coxe Stevenson, Zuni plants (1915); Frank Cushing, Zuni foods (1920); Keewaydinoquay Peschel, Anishinaabe fungi (1998), and the team approach of Wilfred Robbins, JP Harrington, and Barbara Freire-Marreco, Tewa pueblo plants (1916).

In the beginning, ethnobotanical specimens and studies were not very reliable and sometimes not helpful. This is because the botanists and the anthropologists did not come together on their work. The botanists focused on identifying species and how the plants were used instead of including how plants fit into people's lives. On the other hand, anthropologists were interested in the cultural role of plants and not the scientific aspect. Therefore, early ethnobotanical data does not really include both sides. In the early twentieth century, botanists and anthropologists finally collaborated and the collection of reliable, detailed data began.

Modern ethnobotany

Beginning in the 20th century, the field of ethnobotany experienced a shift from the raw compilation of data to a greater methodological and conceptual reorientation. This is also the beginning of academic ethnobotany. The founding father of this discipline is Richard Evans Schultes.

Today the field of ethnobotany requires a variety of skills: botanical training for the identification and preservation of plant specimens; anthropological training to understand the cultural concepts around the perception of plants; linguistic training, at least enough to transcribe local terms and understand native morphology, syntax, and semantics.

Considerable information on the traditional uses of plants is still intact with the tribals. But the native healers are often reluctant to accurately share their knowledge to outsiders. Schultes actually apprenticed himself to an Amazonian shaman, which involves a long term commitment and genuine relationship. In *Wind in the Blood: Mayan Healing & Chinese Medicine* by Garcia et al. the visiting acupuncturists were able to access levels of Mayan medicine that anthropologists could not because they had something to share in exchange. Cherokee medicine priest David Winston describes how his uncle would invent nonsense to satisfy visiting anthropologists.

14.4 ORIGIN AND HISTORY OF MEDICINAL PLANTS

Ethnobotany

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The most remarkable fact concerning the food plants in use in the world today, and for that matter the industrial plants as well, is their great antiquity. Most of them were domesticated from wild ancestors long before the beginning of the historical period, and all available records indicate that they were as familiar to the peoples of the ancient world as they are to us. Comparatively few new plants have been developed during the last 2000 years, although the older ones have been greatly altered and improved in response to the increasing complexity of man's existence. The history of our useful plants and their influence on civilization has always been of interest to botanists and ethnologists. Many investigations have been carried out in an attempt to determine (1806-1893), from a photograph taken in 1866. (Courtesy of the Gray Herbarium, as well as their cultural history. The Work of De Candolle.-The classic work dealing with this phase of botany is De Candolle's "L'origine des plantes cultivées," which appeared in 1883. So careful and painstaking was his work that few of his conclusions have had to be altered in the light of more recent studies. De Candolle (Fig. 127) based his conclusions on a great variety of evidence : the works of Theophrastus, Dioscorides, and other old historians; Chinese writings; archaeological and ethnological data, such as the monuments of Egypt, the ruins of Pompeii, the remains of the Lake Dwellers of Europe, and the Inca ruins of South America; philological indications, involving the names of plants in Hebrew, Sanskrit, and other ancient languages; and botanical conclusions based on distribution, number of varieties, presence or absence of wild types, length of cultivation, and similar matters. He arranged the useful plants in six classes, and it will be interesting to give a few examples of each of these groups:

A. Old world species cultivated for over 4000 years. Almond, date, millet, rice, apple, eggplant, mulberry, sorghum, apricot, olive, soybean, banana, flax, onion, tea, barley, grape, peach, turnip, broad bean, hemp, pear, watermelon, cabbage, mango, quince, wheat and cucumber.

B. Old world species cultivated for over 2000 years, alfalfa, chestnut, mustard, poppy, asparagus, cotton, nutmeg, radish, beet, garden pea, oats, rye, breadfruit, grapefruit, orange, sugar cane, carrot, lemon / pepper, walnut, celery, lettuce, plum, yam, cherry and lime

C. Old world species cultivated probably for less than 2000 years. Artichoke, endive, okra, raspberry, buckwheat, gooseberry, parsley, rhubarb, coffee, horseradish, parsnip, strawberry, currant and muskmelon.

D. New world species of ancient cultivation, more than 2000 years. "cacao, kidney bean, maize, mate, sweet potato and tobacco.

E. New world species cultivated before time of Columbus antiquity not known. Avocado, peanut, cotton, pineapple, guava, potato, Jerusalem, artichoke, pumpkin, quinoa, red, pepper, squash, tomato and vanilla.

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14.5 BOTANICAL DESCRIPTION, CULTIVATION, PROCESSING AND USES OF - MEDICINAL PLANTS

14.5.1 RAUVOLFIA

Botanical Name: *Rauvolfia serpentina* Benth. Ex.Kurz

Family – Apocynaceae Sarpagandha is an important medicinal plant distributed in the foot-hills of Tamil Nadu range, up to the elevation of 1300-1400 m. and almost throughout all over the country. It is an erect evergreen, perennial under-shrub, and 75 cm to 1 m. in height. Root is prominent, tuberous, usually branched, 0.5 to 2.5 cm in diameter. Up to 40 to 60 cm deep into soil. The root possess high alkaloid concentration.

Common Names: Sarphagantha, Pambukala, Serpentina root & Chandrika.

Location: Lowers Tamil Nadu, Uttaranchal, Uttar Pradesh, Kerala etc.

Parts Used: Root

Cultivation

Soil and Climate

The plant requires slightly acidic to neutral soils for good growth with medium to deep well drained fertile soils. Clay-loam to silt-loam soils, rich in organic content are suitable for its commercial cultivation. It grows well in frost-free tropical to subtropical situations under irrigation.

Nursery Raising & Planting

The crop can be propagated by seed, stem cutting and root cuttings. Seed propagation is the best method for raising commercial plantation.

By root cutting: Nearly 5 cm long root cutting are planted during spring season closely in nursery beds containing well matured FYM, sand and saw-dust. The beds are kept moist through watering. The cuttings begin to sprout within 3 weeks. These can be planted in field during rainy season after 8 to 10 cm rains are received; the seedlings are transplanted at 45 cm row to row and 30 cm plant to plant distance. In this manner, an estimated 100 kg of root cuttings are found sufficient for planting one hectare area.

By stem cuttings: Hard wooded stem cutting measuring 15 to 22 cm are closely planted during June in the nursery beds where continuous moisture is maintained.

After sprouting and giving out roots, these plants are transplanted in the main field at given spacing.

By root stumps: About 5 cm of roots, intact with a portion of stem above the collar, are directly transplanted in the field having irrigation facilities.

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By seed: Seed germination in Rauvolfia is highly variable. It is reported to vary from 5 to 30 percent even when only heavy seeds are chosen for sowing purpose. Light and heavy seeds can easily be separated by simple water flotation. Germination of heavy seeds during May-June after soaking them in water for 24 hours was 20-40 percent and 62.77 percent germination was recorded in freshly collected heavy seed lot. In all, 6 kg of seeds are sufficient to raise one-hectare plantation.

In Maharashtra and Madhya Pradesh, April end, in West Bengal first week of May or little later, and in Jammu & Dehradun during third week of May are found to be most time for sowing seed in the nursery. The nursery is prepared by raised beds of 10x10 m. dimension under partial shade made up of one-third of well matured

FYM and leaf mould, and two-thirds amount medium of silt-loam soil. About 500 sq m. seed bed area is sufficient for raising seedlings enough for planting one hectare land. The seeds sown, 2-3 cm apart in rows in shallow furrows during April end. The furrows are then covered with a fine mixture of soil and FYM. Keep the beds just moist by light watering. Germination starts after 15-20 days and continues up to 30 to 40 days. Seedlings are ready by mid-July for transplanting. The seedlings are transplanted at 30 cm distance within the rows spaced at 45 cm. If rains are not received during or immediately after transplantation irrigation is necessary for better stand. Rauvolfia is long duration (18 months) and slow growing crop particularly in the initial stage; thus different intercrops have been tried.

Manures, Fertilisers and Pesticides

The medicinal plants have to be grown without chemical fertilizers and use of pesticides. Organic manures like, Farm Yard Manure (FYM), Vermi-Compost, Green Manure etc. may be used as per requirement of the species. To prevent diseases, bio-pesticides could be prepared (either single or mixture) from Neem (kernel, seeds & leaves), Chitrakmool, Dhatura, Cow's urine etc.

Irrigation

Rauvolfia, if grown in areas which receive rainfall of 150 cm or above well distributed throughout the growing season such as in Assam and Kerala, can be raised and rainfed crop under subtropical conditions. It need regular irrigation where temperature rise high combined with low rain fall during rainy season. It is suggested that 15 to 16 irrigations, amounts to irrigation at 20 days interval in summer and at 30 days interval in winter.

Weeding

The Rauvolfia field should be kept relatively weed-free in the initial period of growth. This means giving two to three weeding and two hoeings in the first year where sole Rauvolfia crop is taken or 5-6 weeding Where Intercrops in Rauvolfia Are Practised.

Harvesting/Post-Harvesting

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Root yields at different age and season have showed that 18 months duration crop produce maximum root yield. Transplanting is done in July, the harvesting period coincides with the shedding of leaves during early autumn season next year. At this stage, the roots contain maximum concretion of total alkaloids. At harvest the root may be found to go up to 40 cm deep in the soil. Harvesting is done by digging up the roots and thin roots are also collected.

After digging the roots are cleaned, washed and cut into 12 to 15 cm pieces for convenience in drying and storage. The dry roots possess upto 8-10 per cent of moisture. The dried roots are stored in polythene lined gunny bags in cool dry place to protect it from mould.

Yield

On an average, root yield vary from 15 to 25 q/ha of dry weight under irrigation depending upon soil fertility, crop stand and management



Rauvolfia Serpentina



Field Cultivation of Rauvolfia

14.5.2 ACONITUM

Botanical Name: *Aconitum heterophyllum* Wall.Ex. Royle.

Family – Ranunculaceae

A herbaceous, erect, Biennial; leaves more or less heteromorphic; flower blue or violet, fruits follicles. Root tuberous in pair's whitish or grey, breaks very easily and taste very bitter. The plant is found in sub-alpine and alpine zone of the Himalayas, between 2400-3600 m altitudes.

Common Names: Aruna, Ativasa, Visa.

Location: Hills of Himachal Pradesh, Uttaranchal, Jammu & Kashmir, Arunachal Pradesh & Sikkim

Part Used: Tuberous root

Cultivation

Soil and Climate

Sandy loam and acidic soil is best for seed germination, survival, better growth and yield. In general, cultivation up to 2200m elevation

having sandy textured soil with rich organic matter is recommended for cultivation.

Nursery Raising and Planting

Germination study of seeds of *Aconitum heterophyllum* can be undertaken at lower altitude in polyhouse as well as in open nursery beds under different experimental conditions. Seeds sown in Styrofoam seedling trays containing sandy soil with litter treatment, gives maximum germinability when seeds were sown 0.5-0.7 cm. sowing depth inside polyhouse during November and December at lower altitude and during

April in open beds at 2200m. Germination as well as true leaf initiation is earlier in sandy soil. Otherwise seedlings remained in cotyledonary stage (pseudomonocotyly) up to 3-4 months. About 44,000 plants planted 1 acre of land. Seedlings raised at lower altitude during winter months are transplanted in nursery beds at higher altitude during April-May, which reduce their vegetative growth period. In open nursery beds seed germination is very low. Plants raised from seedlings have very slow growth and cotyledonary phase (pseudomonocotyly) remained at least for one growth season (3-4 months). Vegetative growth phase is for 3-4 years and at last it leads to reproductive phase. Addition of forest litter or organic manure to the soil increases survivability and growth of seedling at lower altitude.

For vegetative propagation top tuber segment having innovation bud was found more successful. Top tuber segment produces single shoot, which was found more suitable for multiplication in comparison to middle and basal segments. Vegetative propagation was found most successful for multiplication as well as for higher production within short period than cultivation through seedlings.

Manures, Fertilisers and Pesticides

The medicinal plants have to be grown without chemical fertilizers and use of pesticides. Organic manures like, Farm Yard Manure (FYM), Vermi-Compost, Green Manure etc. may be used as per requirement of the species. To prevent diseases, bio-pesticides could be prepared (either single or mixture) from Neem (kernel, seeds & leaves), Chitrakmool, Dhatura, Cow's urine etc.

Irrigation and Weed Control

Beds needed excessive watering/irrigation to decrease the mortality rate of seedlings.

However, watering is not required during monsoon period in cultivated fields.

Irrigation requirement also depends on the texture of soil. Frequent watering is required once at 24hrs interval for 6 months old seedlings at lower altitudes (1800- 2200m) in dry season. Weeding during rainy season is required at weekly interval.

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During winter months irrigation is needed once in a week to retain moisture and weeding at 15-20 days interval is required when plant is cultivated at lower altitude.

Harvesting/Post-harvesting

Harvesting of tubers is recommended after the completion of reproductive phase and maturation of seeds during October-November. Maximum yield is recorded during

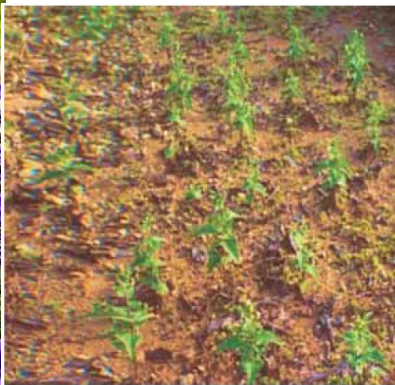
October-November period. However active content (atisine) and other alkaloids content were found maximum when plant were harvested in July-August at the time of onset of flowering period. Further percentage of active contents slightly decreased with maturation of plant.

After completion of reproductive phase at any altitude, plants become mature for harvest and yield good percentage of active contents. Time of completion of reproductive phase differs with the altitude of cultivation. Generally the plants in alpine areas complete their reproductive phase in the last week of October or first of

November while the plants cultivated at lower altitude complete their reproductive phase in the first half of October. Plants raised from tuber cuttings completed their vegetative and reproductive phase within three years. The harvesting period for this species is 3-4 years.

Yield:

Per acre production from mature strands in natural pockets is estimated as 440 kg.



Aconitum heterophyllum

Field cultivation of Aconitum

4.5.3 Botanical Name: *Nardostachys grandiflora*

Family: Valerianaceae

It is an erect, hairy, perennial rooted herb, 10–60 cm high, with stout woody main root. Rootstock is thick, long, covered with remnants of petioles of withered leaves. Stems are generally pubescent upward, and glabrate below.

Common Names: Jatamanji

Location: The species occurs in montane and sub-alpine zones of the Himalayas, from Kumaon to Sikkim, Nepal, and Bhutan, from 3000 m to 5000 m altitude in steep open areas.

Part Used: Rhizomes and roots

Cultivation

Soil and Climate

Seeds are the best propagation material, although vegetative propagation may be undertaken to get a crop within two to three years, if sufficient mother plants are available.

However, initially the planting stock has to be raised through seeds only. Seeds have 80% germination rate when sown in a mixture of soil, sand, and FYM (farmyard manure)/compost in equal quantities in Styrofoam trays.

Leaves are radical as well as cauline.

Radical leaves are large (15–22 cm × 1.5–2.5 cm), six to eight in numbers, longitudinally nerved, slightly pubescent, and narrow down into the petiole, while cauline leaves are sessile, occur in two to three pairs, 2.0 cm × 0.6 cm in size, decrease in size from base to top, and are oblong or sub-ovate in shape.

Rhizome is dark brown, tapering, and densely covered with the remains of old leaves' bases, giving the appearance of a heavy beard, and hence the name jatamansi.

The fibrous rhizome may be 6–9 cm long with about 20–30- cm-long yellowish taproot. A single root may bear 30–50 rhizomes

Irrigation practices

Initially, watering should be done on alternate days at lower altitudes (2000 m) till proper rooting is developed. Later, watering is done at weekly intervals during dry season. Constant humidity should be maintained in the soil avoiding waterlogging.

Weed control

Manual weeding is carried out (fortnightly) during early growth season, and later at monthly intervals or as and when required to keep the crop weed-free.

Disease and pest control

No diseases, insects, nematodes or physiological disorders have been observed in this crop.

Yield and cost of cultivation

At the experimental site at an elevation of 3600 m, the recorded yield was 835 kg/hectare dry roots; plantation was raised through seedlings. At lower altitudes (2200 m), the recorded yield was 670 kg/hectare dry weight after third year of cultivation; plantation was raised through seedlings. The yield may increase in subsequent years if the plant is not harvested for one more year. Input cost is estimated to be Rs 202 000 hectare for three years at lower altitudes.

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Nardostachys grandiflora Field cultivation of Jatamanji

14.5.4 Botanical Name: *Asparagus racemosus*

Family: Liliaceae

Common name: Asparagus

Indian name: Shimai-shadavari, Ammaikodi, Kilwari (Tamil)

Distribution: Tropical and subtropical India

Shatavari is an indigenous medicinal plant used in Siddha and Homoeopathy medicines.

It is estimated that in India, more than 500 tonnes of shatavari roots are needed every year for various medicinal preparations.

MEDICINAL PROPERTIES AND USES

- Shatavari roots are used mainly as galactagogue which stimulates the secretion of breast milk.
- It is applied in improving the lost body weight and also known as an aphrodisiac.
- The root is useful in treating the ailments like dysentery, tuberculosis and diabetes.
- Commonly, it supports to maintain the health by giving immunity to diseases.
- It is considered as very good energy provider to the weak body system.

Cultivation

Soil

- Generally, the crop prefers lateritic, red loamy soils, with adequate drainage.
- Being a shallow rooted crop, it can be easily grown under such shallow and rocky soils where the soil depth is hardly 20-30 cm.

Climate

- The crop survives under varied agro-climatic conditions ranging from temperature to tropical hill regions.
- It can be grown in moderate hills like Shevroys, Kolli and Kalrayan hills and medium elevations of Western Ghat hills under condition where the elevations are between 800 to 1500 m above MSL. It tolerates drought as well as low temperature.

Planting

- It is propagated by root suckers or seeds. For commercial cultivation, root suckers are preferred over seeds.
- The soil is prepared well by digging up to 15 cm depth. The field is divided into convenient sized plots and laid out into ridges at 60 cm apart.
- Well developed root suckers are planted on the ridges.

IRRIGATION AND INTERCULTURE

- The field is irrigated immediately after planting. It is continued at 4-6 days interval until a month and thereafter at weekly interval.
- Frequent weeding is required during its early period of growth.
- Care should be taken to avoid any damage to growing shoots at the time of weeding. Totally, about 6-8 hand weeding is needed to keep crop free of weeds.
- The crop being a climber requires support for its proper growth. For this purpose, 4-6 feet long stakes are used to support the general growth.
- In large scale plantation, the plants are trailed on brush wood pegged in alternate rows.

Harvesting and Yield

A single plant may yield about 500 to 600 g of fresh root. On an average, 12,000 to 14,000 kg of fresh roots can be harvested from one hectare area which on drying may yield about 1000 to 1200 kg of dried roots.



Asparagus racemosus, Field cultivation of Sathavari with Rhizome

14.5.5 Botanical name: *Cammiphora wightii* (Arn)

Guggal (*Cammiphora wightii* (Arn.)) is a small tree or shrub belonging to the family Burseraceae. The species is endemic to the arid western parts of India. Major guggul producing centers are Kutch forest division in Gujarat and Jodhpur forest division in Rajasthan. Gum tapped from the plants is known as oleo-gum-resin (guggul). Guggul is well known medicine in Ayurvedic and Allopathy systems. It is used for

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treating rheumatoid arthritis, obesity and peptic ulcer. It is also astringent and antiseptic. It is also used in preparation of incense.

Family: Burseraceae.

Common Name: Guggul

Medicinal parts: oleo-gum-resin

Distribution:

The species is endemic to the arid western parts of India. Major guggul producing centers are Kutch forest division in Gujarat and Jodhpur forest division in Rajasthan. Gum tapped from the plants is known as oleo-gum-resin (guggul). Guggul is a well-known medicine in Ayurvedic and allopathy systems. It is used for treating rheumatoid arthritis, obesity and peptic ulcer. It is also astringent and antiseptic. It is also used in preparation of incense.

Description of Plant

Commiphora wightii is a small tree growing wild. It is much-branched, grows up to 6 m tall with brown-colored, spine. Bark shiny, ash to yellowish white which also peels off in thin papery rolls. Leaves

Description of Plant

Commiphora wightii is a small tree growing wild. It is much-branched, grows up to 6 m tall with brown-colored, spine. Bark shiny, ash to yellowish white which also peels off in thin papery rolls. Leaves are sessile with serrated margin. The shrub defoliates in winter

Climate and Soil: Guggul usually grows in arid regions, hilly and mountainous terrains. It is also considered as a drought area salinity resistant plant. Guggul grows well with mean annual rainfall of 225-500 mm and temperature ranging from 20-35 °C. It prefers loams to sandy loam soils with pH ranging between 7.5 to 9.0. It prefers to grow well in coarse textured, well drained and calcareous soils.

Propagation:

1. By Seed: Seeds are the major propagation source in nature. In Kutch and nearby arid regions flowers and seeds are produced by *C. wightii* from September to December. South west Monsoon season creates conducive atmosphere for germination. The temperature after monsoon ranges between 25-30°C with high relative humidity is suitable for seed germination. Seed should be soaked in cold water for 24 hours before sowing in nursery bed for better germination.

2. By Cuttings: It can be successfully propagated vegetatively by stem cuttings. Cuttings are planted in June at a depth of 15 cm for raising them in nursery. The rooting begins after 21 days from stem cutting.

Weeding and Irrigation: Weeding and irrigation is necessary up to 2-3 years after planting. In the scarcity of rain it requires irrigation at least 2-3 times during summer and winter season. Excessive weeds affect the growth of plant. So weeding is beneficial in the month of August and September.

Yield: Starting from sixth year the guggul gum yield increases from 200 g to 850 g per plant corresponding to 3200 kg per ha @ 2000 plants per ha.



Guggul(*Commiphora wightii*)

oleo-gum-resin

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14.5.6 Botanical Name: *Ocimum basilicum*

Family: Lamiaceae

Medicinal Parts: Leaves

Common Name: Basil, royal herb, St. Joseph's Wort, Thai basil, Genovese basil, Greek basil, Italian basil, Holy basil, and a wide range of variety names

Distribution: Basil is an aromatic herb from the mint family, sometimes referred to as the "royal herb". Its name derives from the Greek word for king, "basileios". Scientifically known as *Ocimum basilicum*, it's also known as St. Joseph's Wort. Originating in Thailand and India, it is often used as part of ayurvedic medicine as well as for culinary uses. People in Rome believed that it caused madness in men. The ancient Greeks thought that basil was a plant linked to hatred, and that it must be planted while cursing and yelling at the seeds to force them to grow.

Propagation: In addition to sowing basil from seed, a cutting of basil will easily root when placed in water. Select a four-inch section of basil that has not yet flowered. Roots will form within a week. Transplant the basil directly into the garden or container once a healthy root system is apparent.

Cultivation:

Soil: Basil does its best in well-drained, moist soil with a neutral pH. I add a rich compost to the soil at the beginning of the season. Not much more soil amendment is necessary. In fact, if the soil is too rich, basil loses some of its flavor intensity.

Sun: Basil grows well in warm environments that receive about six hours of sun each day. I have a couple of basil plants growing in an area that receives only four hours of sun, but they aren't as prolific as the others. My best basil plants actually grow in an east-facing area that doesn't get the scorching, midday sun.

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Water: Give basil water when the soil is dry to the touch, doing your best to water the plant at its base and not all over its leaves.

Spacing: Depending upon the variety, basil grows anywhere from 12 to 24 inches in height. Space basil plants 12 to 16 inches apart. If you're limited on space or only grow in containers, consider spicy globe basil, which tends to form a small, mounding habit.

Companion planting: Plant basil among other herbs and vegetables with similar lighting and watering needs, like tomatoes or parsley. Some even say tomatoes taste better when they neighbor basil. Plant basil alongside chamomile, lettuce, peppers, and oregano. I even like to keep a few pots of basil on my back porch to deter mosquitoes.

Harvesting and yield:

It's always better to harvest basil before the plant flowers. If you don't have time to harvest any leaves, just pinch off the flowering portion. The flowers are actually edible, but if you pinch them off, the plant can now direct its energy on growing tasty leaves. Also be sure to only harvest up to 2/3 of the entire plant, so it can continue producing.



Basil (*Ocimum basilicum*)

Greenhouse Cultivation of Basil

14.5.7 Botanical name: *Saraca asoca*

Family: Caesalpiaceae

Medicinal parts: Stem bark, flowers, seeds

Distribution: Asoka is distributed throughout India, naturally frequent in South India, Sri Lanka, Orissa, and Assam. The species also occurs in central and eastern Himalayas up to 750 m altitude. It is grown as an avenue tree due to its foliage and fragrant flowers.

Climate and soil

Asoka grows well in moist tropical areas with well-distributed rainfall. It also thrives well in partially shaded locations.

Propagation material

Seeds are the most suitable propagation material. Mature seeds are collected from more than five to six-year-old plants in December–January

Irrigation practices

The crop is raised over high rainfall tracts. During the months without rains, the seedlings require frequent irrigation. Watering of

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grown-up trees is done by forming a ring channel around trees' base to hasten growth.

Harvesting: Flowering in Asoka takes place in the early growth stage.

The plant flowers profusely at six to eight years of age and produces fruits during July to October. The tree survives for about 50 years.

It is often felled after it reaches 20 years of age for collecting bark.

It is cut at a height of 15 cm from the soil level.

If sufficient irrigation and fertilizers are provided, the stumps will regenerate new coppice shoots, which can be harvested again after 10 years.

Alternatively, the bark can be collected without cutting down the tree.

The bark is peeled off in vertical strips with 6 cm interspaces between each strip.

The peeled off area is renewed with fresh bark in one to two years.

Then, the bark on the other areas can be peeled off without cutting the tree.

This non-destructive method should be preferred for harvesting.

Yield

One tonne of dry stem bark per hectare is produced from a sole crop. When grown as mixed crop with coconut, yield is reduced to 0.6 tonne per hectare.



Saraca Tree (*Saraca asoca*)

14.5.8 Botanical name: *Azadirachta indica* Juss.

Family: Meliaceae

Medicinal parts: Leaves, seeds/fruits, bark and wood

Common name: Neem

Distribution: It is grown from the southern tip of Kerala to the Himalayan hills in the tropical to sub tropical and semi arid to wet tropical regions and from the sea level to about 700 m elevation. It has been widely cultivated in India and African countries. In India, it occurs

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throughout the larger parts of the country in the states of Tamil Nadu, Uttar Pradesh, Bihar, West Bengal, Orissa, Delhi, Maharashtra, Gujarat, and Andhra Pradesh.

Climatic Requirements

It generally performs well on areas with annual rainfall varying from 400 - 1200 mm. It thrives under the hottest conditions where maximum day temperature reaches 50 degree Celsius. But it cannot withstand freezing or extended cold.

Soil

Neem grows on almost all kinds of soils including clayey, saline and alkaline soils but does well on black cotton soils. It thrives better than most other trees on dry stony saline soils with a waterless sub-soil or in places where there is a hard calcareous or clay pan near the surface. It does not tolerate inundation. It has a unique property of calcium mining which changes the acidic soil into neutral. Neem also grows well on some acidic soil. It is said that the fallen neem leaves which are slightly alkaline are good for neutralising acidity in the soil.

Planting Techniques

Neem can be easily raised through direct sowing, entire / polypot seedlings or root-shoot cuttings. For degraded areas direct sowing is more successful. Entire / polypot seedlings or rootshoot cuttings are more relevant for agro-forestry / silvi pasture and road side avenue plantations. Direct sowing is done either by dibbling in bushes, broadcast sowing, line sowing, sowing on mounds or ridges, sowing in trenches in sunken beds in circular saucers or by aerial sowing. The choice varies with edaphic, climatic, biotic and economic conditions of the site. Planting in pits is carried out by using 20 to 45 cms tall seedlings. Taller ones promise better survival. Planting of stumps prepared from a year old seedlings in crowbar holes also gives good results.

Harvesting, and Yield

Neem starts bearing fruits after 5 years and comes to full bearing at the age of 10-12 years. Fruit yield is 5-20 kg per tree per year in the initial years. A mature tree produces 35-50 kg fruit/year. Oil yield varies from 40-43% of seed on dry weight basis. Highest oil content has been reported from Virudhunagr region of Tamilnadu (43.2%), while the lowest oil yield of 32.4% has been reported from Jaisalmer region. It has been observed that as rainfall in an area increases oil content also increases. Among the International provenances tested, Bangladesh provenance has yielded maximum oil content (48.6%).

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Neem Tree

Check your Progress

1. Write botanical name, family, important plant part and uses of following medicinal plants
a) *Rauwolfia*, b) *Aconitum*, c) *Jatamansi*
2. Define Ethnobotany
3. Write an essay on cultivation and processing and uses of following medicinal plants
a) Sathavari, b) Goggul, c) Basil, d) Saraca
4. Write about botanical name and uses of potential medicinal plant
Neem

14.8 LET US SUM UP

In this unit you have learnt about the general account on ethnobotany, cultivation of medicinal plants and their uses. Also describe the cultivation practices, disease and their control by using the medicinal plants.

14.9 UNIT – END EXERCISES

- Origin and history and cultivation of economic botany
- Botanical description, harvesting, extraction and uses of fatty oils and vegetable fats
- Fibers and timbers
- Ethnobotany and medicinal plants

14.10 ANSWERS TO CHECK PROGRESS

1. Economic plants are defined as being useful either directly, as in food, or indirectly, as products we use or that enhance the environment. Plants have been used to control body functions and fertility, to poison, and to make clothing, paper, and rubber.
2. Fats and oils are used in our diets to provide us with energy. They play an important role in the transport of vitamins which are soluble in fats around the human body. Many fats and oils are obtained from plant sources (sunflower oil, palm oil, coconut oil) and animal sources (lard, cod liver oil).
3. The most used plant fibres are cotton, flax and hemp, although sisal, jute, kenaf, bamboo and coconut are also widely used. Timber plants are usually medium or large trees, which are

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cut to extract the wood. This material will be used for certain purposes such as construction, paper, etc. Timber trees are broadly classified into trees of soft, semi-hard and hardwoods.

4. Ethnobotany defined as the scientific study of the traditional knowledge and customs of a people concerning plants and their medical, religious, and other uses. A medicinal plant is a plant that is used with the intention of maintaining health, to be administered for a specific condition, or both, whether in modern medicine or in traditional medicine.

14.11 SUGGESTED READINGS

1. Sambamurthy, 2008, A Textbook of Modern Economic Botany, 1st edition, CAS publishers & Distributors Pvt, Ltd, ISBN:8123906293
2. Ashwin Dutt, 2008, Economic Botany, 1st edition, Aahyayan Publishers & Distributors, ISBN: 8184350694

DISTANCE EDUCATION -CBCS (2018-19 Academic Year Onwards)

Question Paper Pattern (ESE) – Theory (PG)

Time: 3 Hours
Marks

Maximum: 75

Part- A (10 X 2=20 Marks)

Answer all questions

1. Define Ecology
2. What is Ecotone
3. Herbivory
4. What is Genetic Biodiversity?
5. Who developed Hotspot?
6. Explain Patent
7. FlavrSavr tomato
8. Botanical name and uses of Clove
9. Explain Sun Hemp
10. Sathavari

Part -B (5 X 5 =25)

Answer all questions choosing either (a) or (b)

11. a) Differentiate between Biotic and Abiotic components
Or
b) What do you understand edge effect and edge species? Write a note
12. a) Compare J shaped pattern with s shaped pattern of population
Or
b) Write notes on commensalism with one suitable example
13. a) Give an account of biogeographically regions of India
Or
b) Write short notes on Red list plants
14. a) Write about patenting the biological materials
Or
b) Write short notes on flavrsavr Tomato
15. a) Explain about botanical description and economic uses of Ginger
Or
b) Give botanical names of three important timber yielding plants of India

Part – C (3 X10 =30 Marks)

(Answer any 3 out of 5 questions)

16. Discuss briefly the abiotic components of an ecosystem
17. Distinguish between population and community
18. Describe the role of the wildlife in modern agriculture
19. Discuss briefly about case study on Basmati rice
20. Write an essay on cultivation and processing and uses of following medicinal plants
a) Sathavari, b) Goggul, c) Basil, d) Saraca