BOT(N)-120 & BOT(N)-120L

B.Sc. I Semester

ECONOMIC BOTANY AND BIODIVERSITY CONSERVATION

DEPARTMENT OF BOTANY

SCHOOL OF SCIENCES

UTTARAKHAND OPEN UNIVERSITY, HALDWANI

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UNIT-1 CENTRES OF ORIGIN OF CROP PLANTS

Contents

1.1 OBJECTIVES

After reading this unit student will be able-

- To know the centers of plant origin.
- To study the centers of plant diversity.
- To differentiate between the centers of origin and diversity.
- To study the uses of centers of plant origin in relation to plant breeding

1.2 INTRODUCTION

Plant breeding is evolution in human hands where new forms of plants with respect to appearance, performance and adaptability are created. Evolution takes millions of years to modify the plants for survival under natural conditions but plant breeding aims to change plants in accordance with human needs. Over a short period of only few years, both these processes of modifying plants however, act as genetic differences among individuals to sort out the most successful ones under natural or human care. In contrast to the long history of evolution under natural selection, plant breeding literally started with the origin of agriculture about 10,000 years ago when initiated domesticating wild species as crop plants. The forces of natural selection acted on genetic variation to favor the most competitive plants as new species under the new sets of environments.

Fig. 1.1 Nikolai I. Vavilov

Nikolai I. Vavilov proposed that crop plants evolved from wild species in the areas showing diversity and termed them as primary centers of origin. It is known that with the movement of man, the crops moved to other areas from these areas. But in some areas, certain crop species show considerable diversity of forms although they did not originate there. Such areas are known as secondary centers of origin of these species.

The center of origin is also considered the center of diversity. Vavilov centers of origin are regions where a high diversity of crop wild relatives can be found, representing the natural relatives of domesticated crop plants. Later in 1935 Vavilov divided the centers into 12 centers known as Vavilov Centers or Chinese Centers of plants.

1.3 CENTERS OF ORIGIN OF PLANTS

What is a center of origin? What is a center of diversity? What is the difference between them? How they defined and used? The answers to that and other questions are answered in this review. “The center of origin” and “center of diversity” have been used interchangeable. Though the two concepts are related and highly intertwined there is a distinction between lines of diversity is frequently used to identify the other, though the principle behind centers of origin and diversity applies to all organisms. They are most often used in relation to plants, particularly in plant breeding and studies of crop domestication**.**

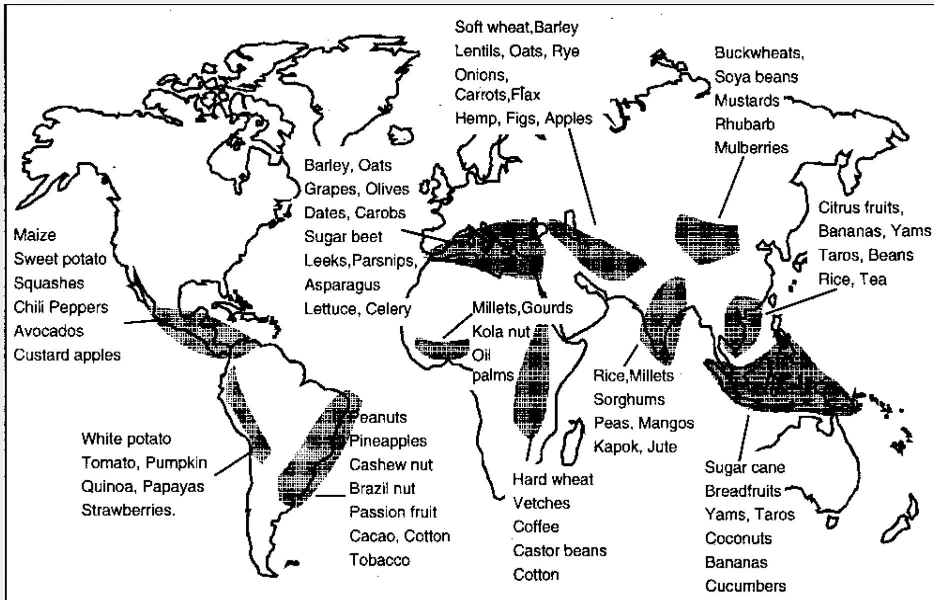


Fig. 1.2 Geographical regions of crop origin in the world

Definition: The center of diversity of a plant is defined as the geographic area wherein the plant exhibits the highest degree of variation. This variation manifests itself both at the population and genetic levels. That is the centers of diversity is where the highest number of cultivated types and wild relatives, as well as gene variants (alleles), exists. Based on the principle that it is only over time that genetic variation can be accumulated, the center of diversity often corresponds to the area where the plant has existed the largest variety.

The center of origin of a plant is that location where it is considered to have first appeared. The primary criterion is identifying a center of origin is the presence of wild relatives. The centers of origin and diversity are highly co-related, they do occasionally diverge. This happens when there is a high variation in cultivated crops, but no or few wild relatives. The variation occurs due to environmental forces and human intervention that may have conspired to increase a plant’s diversity away from its site of origin. A plant species may also have more than one center of origin or diversity.

History: The center of origin was first proposed by the Russian Scientist Nikolai Vavilov (1887- 1943). Vavilov headed what was to be eventually named the Vavilov. All Union Institute of Plant Industry from 1920 to 1940. One of his mission was to collect crop relate germplasm for use in national plant breeding projects.

During his exploration, Vavilov observed that crop diversity tends to be concentrated around specific regions. He proposed that these concentrations of high variability indicated the regions

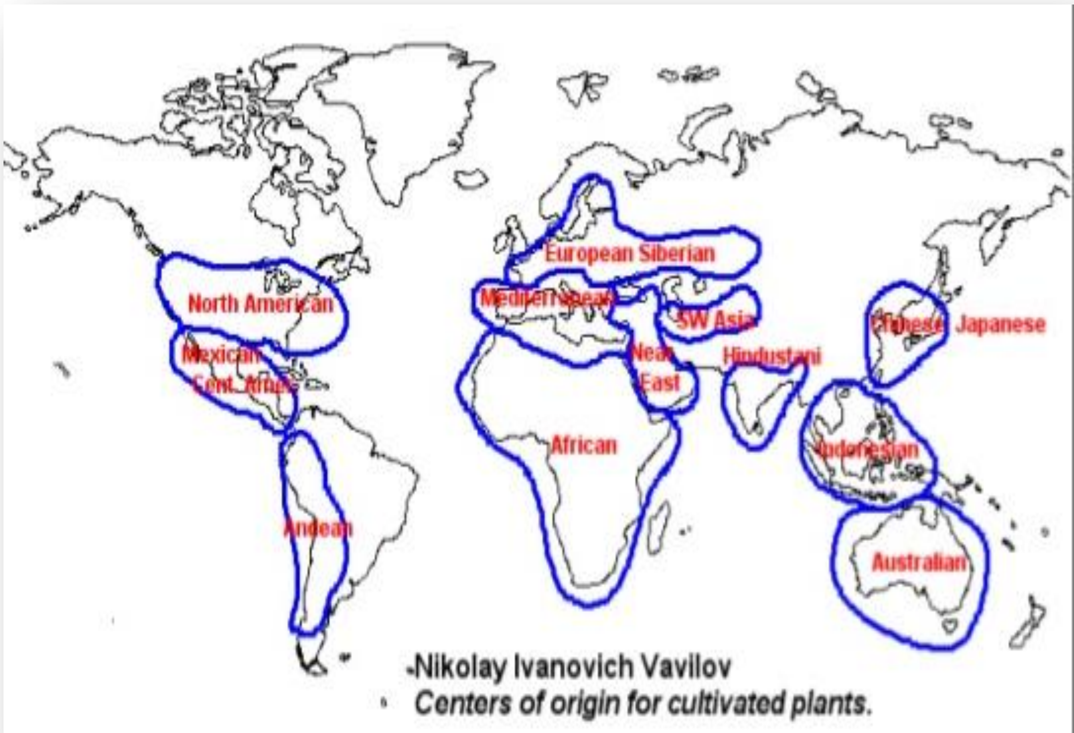


Fig.1.3 Nikolay Ivanovich Vavilov Centres of Origin for cultivated plants

where domestication of these crops began. This concept went against the prevailing view that cultivation of plants started randomly all over the world. In 1926, Vavilov published his theories in his **"Studies on the Origin of Cultivated Plants"**. He identified eight primary areas of diversity and origin of cultivated plants. These areas came to be known as the Vavilov Centers.

The ancient plant breeder's or the stone - age people domesticated all the major food and fiber plants that feed and cover the vast human population today. It is surprising that in some cases the present day cultivated plant forms are so strikingly different from their parental wild (natural), types that makes us to think about their progenitors and the transformation of characters. These transformations were accomplished by primitive plant breeders and not by modern scientists. Even in the early ages farmers were sedentary and tended to occupy a certain area for prolonged period of time than other people who are either nomadic or did not take to farming. During this period they developed new array of varieties of different crop plants to their special need adapted to specific nitches for different crops. After collection of best selected varieties the farmers would move out to other greener pastures and were growing. To carrying the plants from place to place, practiced by our ancestors has been the most important and crucial factors in the development of agriculture throughout the world. While shifting to new areas the shifting to new areas the varieties could come into contact with the distinct races of the same crop and occasional natural crossing between these races. This resulted in a marked increase in the genetic variation.

Alphonse de Candolle was the first botanist who attempted to locate the origin of crop plants. He published a book named "Origin of Cultivated Plants" in 1882 which was reprinted in1959. In his book he used the information on distribution of wild relatives, history, linguistic derivatives, archeology and patterns of variation. Nikolai Ivanovich Vavilov (N. I. Vavilov), the Russian explorer, geneticist and agronomist organized worldwide explorations of a large number of cultivated crops, vegetables, fruit trees, forages and fodder crops plantation crops and wild and related species of economic use and their samples were grown in the appropriate environments and studied for botanical and economic purposes.

N. I. Vavilov proposed that crop plants evolved from wild species in the areas showing diversity and termed as Primary Centers of Origin. From these areas these crops moved to other areas with the movements of man. But certain crop species show considerable diversity of forms in some areas although they did not originate there. Such areas are known as Secondary Centers of Origin of these species. Vavilov has suggested eight main centers of crop origin as below:

Table-1: Centre of Origin of crops according to Nikolai Ivanovski Vavilov

S.No.	**Centre**	**Main Centers**	**Crop Originate**
1.	Chinese	Central & Western China	Reddish, Apricot, Peach, Litchi, Citrus, Soybean
2.	Hindustan	Parts of India & Burma	Rice, Soybean, Cotton, Brinjal, legumes
3.	Central Asiatic	Pakistan, Afghanistan, Punjab, Kashmir, Parts of USSR	Wheat, Pea, Lentil, Apple, Spinach
4.	Near Eastern	Middle East countries	Barley, Wheat, linseed, Grape
5.	Mediterranean	Mediterranean sea	Wheat, Beans, Cabbage, Cauliflower, Sugar beet
6.	Abyssinian	Ethiopia & Eritrea	Coffee, Sesame, Lady's finger
7.	Central America	Mexico & Neighbouring	Maize, Beans, Chili, Cotton, Pumpkin
8.	South America	Peru, Equator, Bolivia & Egyptian	Cotton, Tobacco, Sweet potato Papaya.

1.4 DOMESTICATION AND INTRODUCTION OF CROPS

Selection of best varieties of plants for future from such hybrid populations led to the development of new derivatives having higher potential and adaptation capacity. The plant breeders have been repeated such a cycle over thousands of years by millions of individuals in many parts of the world, resulting in the creation of an immensely rich heritage of germplasm of each species comprising not only the cultivated varieties but also the weedy and wild species which forms the base of plant genetic resources. The genetic variability has been introduced into plant populations primarily by the occasional movement of agricultural people from place to place or by natural but intermittent introgressive hybridization with weedy races and even with wild relatives of crop mixed with spontaneous mutation and the practice of wide scale growing of varietal mixture.

Collection of superior quality plant species from different parts of world the plant breeders practiced the technique of domestication of such plant species along with the animals etc. However, domestication refers to the process whereby a population of animals or plants becomes accustomed to human provision and control the plant domestication has been defined in various ways as below-

1. The process of bringing wild plants under human management is referred to as plant domestication.

2. The process of bringing wild plants under cultivation by humans is called plant domestication. These domesticated plants are grown on farms and become dependent upon humans for propagation. Domestication changes the physical characteristics of the plants under domestication.

3. The word domestication is used as a synonym of taming, though this word can apply to a single animal, while domestication concerns a population or a species as a whole.

4. Domestication is the process of hereditary recognition of wild plants into domestic and cultivated forms dependent upon the interest and need of people or strictly we can say that it shows the initial stage of human mastery of wild animals and plants.

Actually in certain situations plant breeding may lead to the domestication of wild plants. Domestication of plants is an artificial selection process conducted by humans to produce plants that have more desirable traits than wild plants and which renders them dependent on artificial environments for their continued existence.

Domestication has various purposes as -

The man has brought wild plants from nature under his control and domesticated them for various purposes. Primarily plants have been domesticated for five main purposes viz.

i) Plants domesticated for large - scale food production are generally known as crops including grains, vegetables and fruit crops.

ii) Clothes: Plants domesticated for large cloth productions are referred to as fiber clothes including cotton, jute, sun hemp etc.

iii) Shelter: Plants domesticated for large scale wood production are referred to as timber trees. Such plants are grown for use in house for window, doors and furniture.

iv) Aesthetic: Plants domesticated for decoration purposes are referred as ornamental plants. Such plants are grown in and around the home and are usually known as ornamental or home plants.

v) Medicine: Plants grown for large scale medicine production are called medicinal plants. These plants are used for treatment of various human and animal diseases.

Domestication and its effects

Domestication is the first step of making the wild species to cultivated plants to bring the wild species under human management according to their need. This process is known as domestication, or in other words domestication of plants is the change of ideo type to adopt them better to manmade (artificial) environment. Due to natural selection or human selection the wild species get changed to cultivated species under domestication. While in nature there is continuous selection by natural forces like temperature, weather, soil, pests, diseases etc. The best suited genotypes acclimatized in the given environment and leaves behind others which are less adaptive in nature. Under domestication most of the characteristics of wild species have been also affected, which involves three processes like mutation or natural selection, hybridization and genetic recombination.

The concept of centres of diversity as centre of origin served as very useful purpose for the future explorers and collectors of plants and many of these areas still remain rich sources of variations. But Vavilov further observed that for some crops the centre of diversity did not include wild relatives of the crops as if these were not centers of origin. Wheat and barley exhibited enormous variation in Abyssinian Centre but no wild relatives were traced here suggesting their domestication in some other areas. Vavilov explained this pattern of distribution in the form of two types of centers.

Primary Centre: Geographical- areas where a crop originated, and had maximum diversity was termed as primary centre.

Secondary Centre: Vavilov believed that for some crops the wild progenitors migrated to other place from the centre of origin and were domesticated where these further developed into advanced and improved differential types through introgression of gene from new types of wild and weedy plant's such regions of diversity were referred to as secondary centres of origin. The primary centre of maize is Mexico but a secondary centre of waxy maize has developed in China. Another example is the Ethiopian centre where rich variability for tetraploid wheat was reported but there was not a single wild species in Ethiopia.

The Process of Domestication: Generally it is believed that the main factors responsible for plant domestication are- i) natural selection ii) spontaneous (natural) mutation and iii) carefully controlled selective breeding for many of the collective changes associated with domestication. Natural selection and selective breeding have been played some important role in the domesticating throughout history.

Historically, domestication of wheat provides the examples of natural selection and mutation together can play a key role in the process. As the wild wheat fall to the ground to reseed itself when it is ripe, while the domesticated wheat stay on the stem when it is ripe. There is evidence that this importance and critical change came about as a result of a random mutation near the beginning of a cultivation of wheat only due to this mutation wheat harvested and became the seed for the next crop. This wheat was much more useful to farmers and became the basis for the various strains of domesticated wheat that have since been developed. The example of wheat has led some one to speculate that mutations may have been the basis for other early of instances of domestication.

Origin of Crop Plants

1. Origin of Rice *(Oryza sativa)*: Rice or *Oryza sativa* had originated in South and South - East Asia in 300 B. C. The cultivated forms of rice might have been originated from the wild species of rice namely *Oryza perennis*.

Fig.1.4 Domestication of *Oryza sativa*

After that rice moved to China and to Africa and America from India where during domestication three different forms have been originated viz. *indica japonica* and *indica javonica*. Many morphological and physiological characters have occurred during domestication to acclimatize to changed habitats as from normal levels and open sun to shady swamps. Changes in leaf size and shape, grain character and other plant type characters differentiated *Oryza sativa* into three forms.

Species A (with 5 sets of chromosomes abcde) X Species B (with 5 sets of chromosomes a'b'c'd'e')

↓

Hybrid
2n = 20
(aa' bb' cc' dd' ee')

↓ Duplication of two chromosomes

Cultivate *Oryza sativa*
2n = 24 (a a' a")
(a a'a" b b'b" c c'c" d d'd" e e' e")

2. Origin of Wheat: The common wheat *Triticum aestivum* might have been originated about 6,000 years ago in Afghanistan and South Western Himalayas and then moved with man four species of wheat are cultivated e.g. *T. durum, T. eastivum. T. tergidium* and *T.dicoccum* which are allopolyploids. The plant type has get changed with the major changed character in non- brittle rachis during domestication**.**

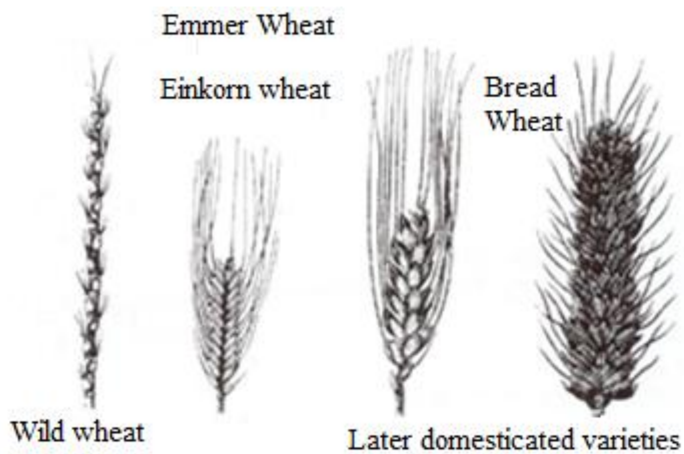


Fig. 1.5: Domestication of wheat

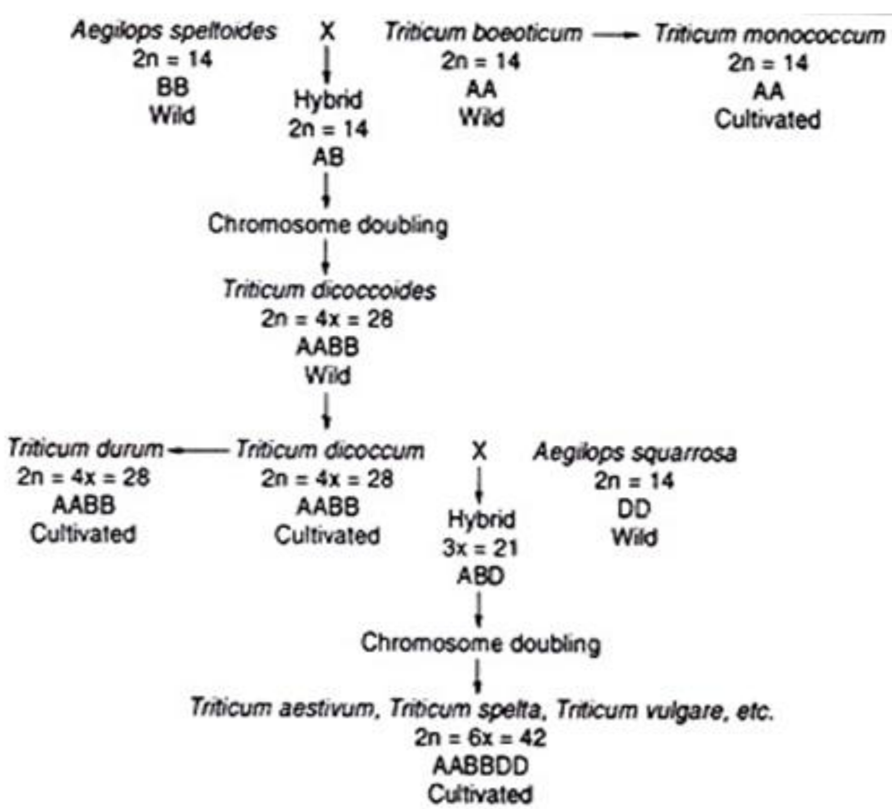


Fig. 1.6 Origin of tetraploid and haxaploid cultivated wheat from new ancestors

Origin of Cotton: Cotton or the Gossypium species is cultivated for fiber production. Out of four species of cotton under cultivation are diploid and rest two are tetraploids. The diploid species of cotton have been originated about 2000 B.C. during Indus civilization. Two species moved to Africa from India and there during domestication the tetraploid species have originated. During domestication the major character has been developed in the corboluted lint and its spinnability. *G. arborium,* G. *herbaceum,* are diploid species whereas G. *hirsutum, G. barbadense* are tetraploid species. While the new world cotton is an allopolyploid.

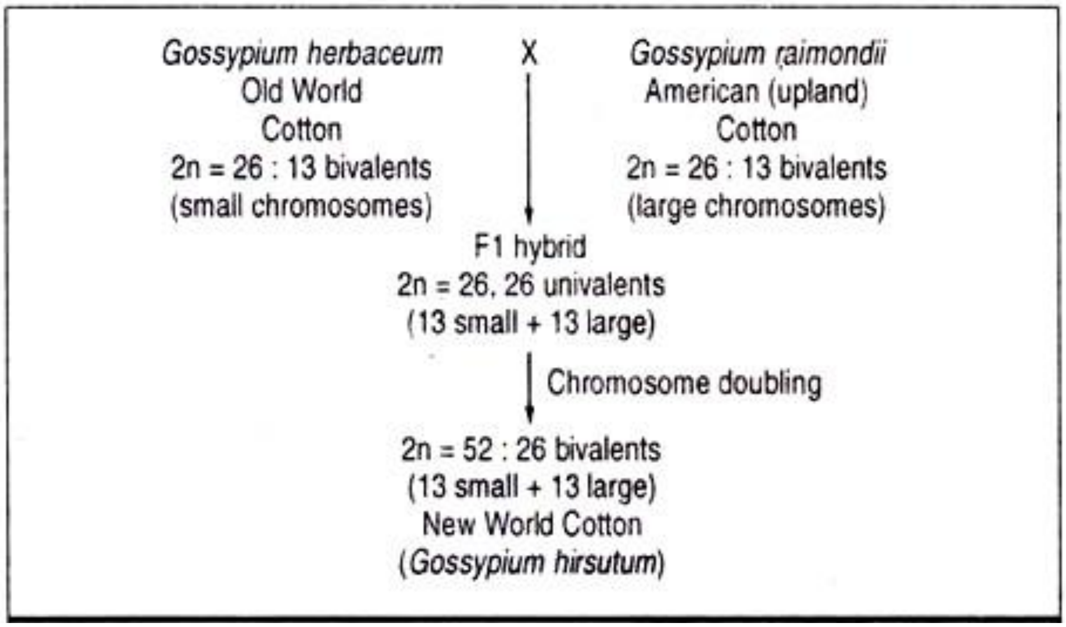


Fig.1.7: Origin of new world cotton from old world and American cotton

Origin of Tea: The centre of origin of tea might have been reported in central China and then differentiated into two types the small leaves china type and broad leaved Assam type. The China type tea *Camellia sinensis* further differentiated and domesticated in South China which has been introduced into India in the early part of 19th Century and the Assam type tea *Camellia assamica* had the secondary Centre of origin in North East India.

Centre of Origin of Maize: Maize also known as corn, is a large grain plant first domesticated by indigenous people in Mexico. Maize was domesticated from its wild grass ancestor more than 8,700 years ago, according to biological evidence uncovered by researchers in Mexico' Central Balsas River Valley. This is the earliest dated evidence- by 1,200 years- for the presence and use of domesticated maize. Maize is the most widely grown grain crop throughout the America, with 332 million metric tons annually in the United States alone. Approximately 40% of the crop- 130 million tons is used for corn ethanol.

The studies carried out at the beginning of the century by Vavilov and others. Vavilov showed that the genetic diversity of cultivated plants are concentrated in certain regions of the world, which they called centres of Origin and diversity.

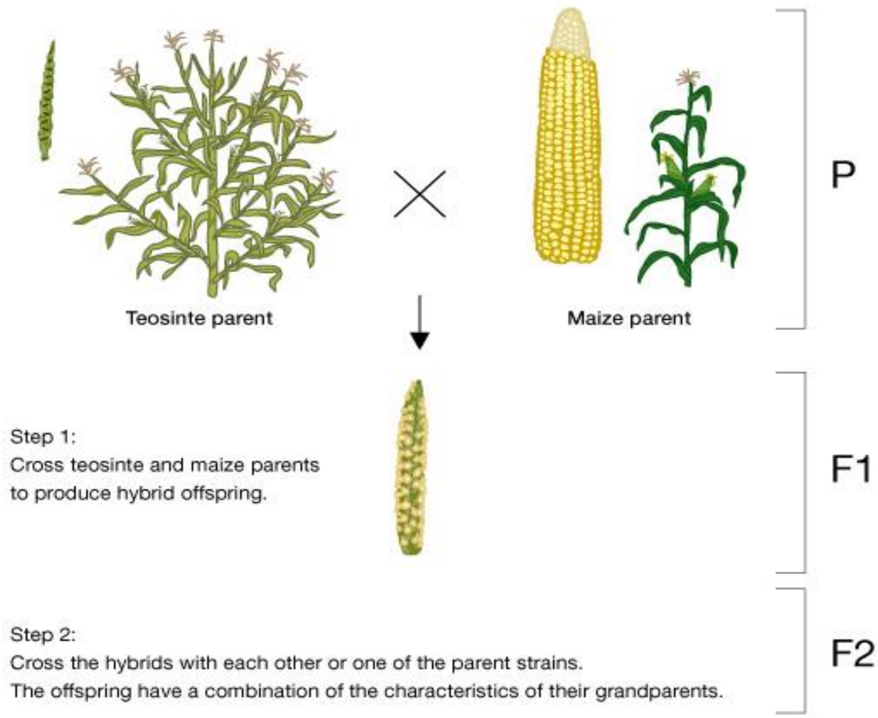


Fig.1.8 Origin of Maize

1.5 SUMMARY

The centre of origin of a plant is that location where it is considered to have first approved. The primary criterion in identifying a centre of origin. A centre of origin (or centre of diversity) is a geographical area where a group of organisms either domesticated or wild, fiber developed its distinctive properties. Nikolai I. Vavilov initially identified 8 of these later subdivided them into 12 in 1935. The study of centres of origin and diversity is helpful in plant breeding and genetic research. The genetic variation in these centres often serves as a rich reserve of genetic material for the improvement of cultivated crops. Genes for disease, pest and stress resistance, and natural quality are just some of the resource that can be found in these areas.

1.6 GLOSSARY

Acclimatization: Adaptation of a variety to new environment.
Biodiversity: The variability among the living organisms for all sources of soil, water, air or associated with other organisms.
Centre of Origin: The areas of origin of cultivated plant species.

Domestication: The process of bringing a wild species under human management.
Genome: The entire complement of genetic material of an organism or the haploid set of chromosome of any eukaryote.
Hybridization: Crossing between two different strains.
Introduction: Taking a variety into a new area.
Plant Breeding: Plant Science involved in changing the genotype of plants resulting in improved and more useful variety.
Transformation: A process involving introduction and expression of foreign gene (transgene) in the recipient plant.
Variation: The occurrence of difference among individuals due to genetic causes or environmental differences.
Variety: A strain released for commercial cultivation.

1.7 SELF ASSESSMENT QUESTION

1.7.1 Fill in the blanks-

1. The centre of origin of tea might have been reported in ____________.
2. The central China tea differentiated into two types ______China type and ______Assam type.
3. The botanical name of China tea is ___________.
4. The botanical name of Assam tea is _______.
5. Nikolai Vavilov has suggested _______ main centres of crop origin.
6. Rice (*Oryza sativa*) is originated in _______ and ____________.
7. The cultivated forms of rice might have been originated from the wild species of rice namely_______.
8. The common wheat *Triticum* might have been originated about _________ years ago in and ________ ____________ Himalaya.
9. In India ___________ species of wheat are cultivated.
10. The cultivated species of wheat in India are ________, ________, ________ and _______.
11. All the cultivated wheat species in India are ____________.
12. Domestication of plant is an __________ process conducted by____________.

1.7.1 Answers Key: 1. Central China, 2. small leaved, broad leaved, 3. *Camellia chinensis*, 4. *Camellia assamese*, 5.eight, 6. South & South East Asia, 7. *Oryza perennis*, 8. 6,000, Afghanistan and South Western**,** 9. Four, 10. *Triticum durum, T. eastivum, T. tergidium & T. dicoccum*, 11. Allopolyploids, 12. Artificial selection, Humans.

1.8 REFERENCES

- B. D. Singh (1983) Plant Breeding Principles and Methods. Kalyan Publication, New Delhi.

- G. S. Chahal S.S. Gosal (2002), Principles and Producers of Plant Breeding Biotechnological and Conventional Approaches. Narosa Publishing House, 22 Daryaganj, New Delhi, 110002, (ISBN 81-204-0087-9).
- Phundan Singh(2010). Essentials of Plant Breeding, Published by Mrs, Usha Raj Kumar for Kalyan Publishers, New Delhi, 110002.
- Sanjay Kumar Singh (2005). Plant Breeding, Campus Book International 4831/24 Prahlad Street, Ansari Road Daryaganj , New Delhi 110002 (ISBN 81-8030-083-8).

1.9 SUGGESTED READINGS

- Deepak Kar and Soma Halder (2007**).** Plant Breeding Biometry Biotechnology,New CentralBo**ok** Agency (P) Ltd**.** London.
- H. K. Chaudhary (1996). Elementary Principles of Plant Breeding (2nd Edition) Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi (ISBN 81-204-0087-9).
- https:// www.Google .Com.

1.10 TERMINAL QUESTIONS

1. Define domestication and describe its main effects on various plant traits?
2. Describe briefly the purpose of plant domestication?
3. Describe briefly centres of origin of tea, maize and cotton?
4. Define primary and secondary centres of crop origin?
5. Describe the contribution of Vavilov for centres of crop origin?
6. Write short notes on center of origin of crop plants and domestication**?**
7. What do you mean by domestication? Discuss the origin of crop plants- rice, wheat, cotton, and tea?
8. Define the purpose of introduction, its uses, merit and demerits?
9. Define the differences between center of origin and center of diversity of crops?
10. Write short note on Nikolai Ivanovski Vavilov?

UNIT-2 CEREALS, MILLETS AND LEGUMES

Contents

2.1 OBJECTIVES

After reading this unit students will be able-

- To study origin, domestication, genetics, cultivation and production of cereals, millets and legumes.
- To establish link between biology and anthropology and exploiting ways humans use cereals, millets and legumes for food and other purposes.

2.2 INTRODUCTION

Economic botany is the commercial exploitation of plants by people. It contributes significantly to anthropology, biology, conservation, botany, and other related field of science.

Economic plants are defined as being useful either directly, as in food, or indirectly, as products we use or that enhance the environment. Plants that humans use for food are of high economic importance. The present chapter describes commercial use of cereals, millets and legumes including anthropology, biology, cultivation, production, conservation, botany and related aspects of these food crops.

2.3 CULTIVATION, PRODUCTION AND USES OF CEREALS AND MILLETS

2.3.1 Wheat

Wheat (*Triticum* spp.) is a cereal grain that belongs to the family Poaceae (family of grasses). It originates from the Levant region of the Near East but now cultivated worldwide. Wheat represents staple food in most countries in the world and inevitable part of human life. Proteins and starch isolated from wheat have application in numerous industries. The world production of wheat was 713 million tons in 2014, making it the third most-produced cereal after maize (1,016 million tons) and rice (745 million tons).

World trade in wheat is greater than for all other crops combined. Globally, wheat is the leading source of vegetable protein in human food, having a higher protein content than other major cereals, maize (corn) or rice. There are six wheat classifications: 1) hard red winter, 2) hard red spring, 3) soft red winter, 4) durum (hard), 5) hard white, and 6) soft white wheat. The hard wheat has the most amount of gluten and is used for making bread, rolls and all-purpose flour. The soft wheat is used for making flat bread, cakes, pastries, crackers, muffins, and biscuits.

Origin and domestication

Wheat is one of the first cereals known to have been domesticated. The archaeological record suggests that this first occurred in the regions known as the Fertile Crescent. Cultivation of wheat began to spread beyond the Fertile Crescent after about 8000 BC. The spread of cultivated emmer wheat (***Triticum** turgidum* subsp. **dicoccum**) has been traced starting in the Fertile Crescent sometime before 8800 BC. Archaeological analysis of wild *emmer* (*T. dicoccoides*) indicates that it was first cultivated in the southern Levant with finds dating back as far as 9600 BC. Genetic analysis of wild einkorn (*T. monococcum*) wheat suggests that it was first grown in the Karacadag mountains in south-eastern Turkey. The cultivation of emmer reached Greece, Cyprus and India by 6500 BC; Egypt shortly after 6000 BC, and Germany and Spain by 5000 BC. By 3000 BC, wheat had reached England and Scandinavia. A millennium later it reached China. The first identifiable bread wheat (*T. aestivum*) with sufficient gluten for yeasted breads has been identified using DNA analysis in samples from a granary dating to approximately 1350 BC in Greek Macedonia.

Genetics

Wheat genetics is more complicated than that of most other domesticated species. Some wheat species are diploid, with two sets of chromosomes, but many are stable polyploids, with four sets of chromosomes (tetraploid) or six (hexaploid). Einkorn wheat (*T. monococcum*) is diploid (AA, two complements of seven chromosomes, 2n=14). Most tetraploid wheats (e.g. emmer and durum wheat) are derived from wild emmer, *T. dicoccoides*. Wild emmer is itself the result of hybridization between two diploid wild grasses, *T. urartu* and a wild goatgrass such as *Aegilops searsii* or *A. speltoides*. The hybridization that formed wild emmer (AABB) occurred in the wild, long before domestication, and was driven by natural selection. Hexaploid wheats evolved in farmers' fields. Either domesticated emmer or durum wheat hybridized with yet another wild diploid grass (*A. tauschii*) to make the hexaploid wheats, spelt wheat and bread wheat. These have three sets of paired chromosomes, three times as many as in diploid wheat.

Genes for the 'dwarfing' trait, first used by Japanese wheat breeders to produce short-stalked wheat, have had a huge effect on wheat yields world-wide, and were major factors in the success of the Green Revolution in Mexico and Asia, an initiative led by Norman Borlaug. Dwarfing genes helped prevent the problem of lodging, planting of semi-dwarf wheat worldwide increased yields and responded better to nitrogenous fertilizer.

In 2012, an essentially complete gene set of bread wheat has been published. Random shotgun libraries of total DNA and cDNA from the *T. aestivum* cv. Chinese Spring (CS42) were sequenced. This sequence data provides direct access to about 96,000 genes, relying on orthologous gene sets from other cereals and represents an essential step towards a systematic understanding of biology and engineering the cereal crop for valuable traits.

Plant breeding

In traditional agricultural systems wheat populations often consist of landraces, informal farmer-maintained populations that often maintain high levels of morphological diversity. Although landraces of wheat are no longer grown in Europe and North America, they continue to be important elsewhere. The origins of formal wheat breeding lie in the nineteenth century, when single line varieties were created through selection of seed from a single plant noted to have desired properties. Modern wheat breeding developed in the first years of the twentieth century and was closely linked to the development of Mendelian genetics. The standard method of breeding inbred wheat cultivars is by crossing two lines using hand emasculation, then selfing or inbreeding the progeny. It takes ten or more generations before release as a variety or cultivar in conventional plant breeding. The major breeding objectives include high grain yield, good quality, disease and insect resistance and tolerance to abiotic stresses, including mineral, moisture and heat tolerance. Wheat has also been the subject of mutation breeding, with the use of gamma, x-rays, ultraviolet light, and sometimes harsh chemicals. The varieties of wheat created through this methods are in the hundreds (varieties being as far back as 1960), more of them being created in higher populated countries such as China.

Nutritional value

Much of the carbohydrate fraction of wheat is starch. Wheat starch is an important commercial product of wheat, but second in economic value to wheat gluten. The principal parts of wheat flour are gluten and starch. In wheat, phenolic compounds are mainly found in the form of insoluble bound ferulic acid and are relevant to resistance to wheat fungal diseases. Alkylresorcinols are phenolic lipids present in high amounts in the bran layer (e.g. pericarp, testa and aleurone layers) of wheat and rye (0.1-0.3% of dry weight).

Production

Wheat is grown on more than 218,000,000 hectares, larger than for any other crop. With rice, wheat is the world's most favoured staple food. It is a major diet component because of the wheat plant's agronomic adaptability with the ability to grow from near arctic regions to equator, from sea level to plains of Tibet, approximately 4,000 m above sea level. In addition to agronomic adaptability, wheat offers ease of grain storage and ease of converting grain into flour for making edible, palatable, interesting and satisfying foods. Wheat is the most important source of carbohydrate in a majority of countries.

In the Punjab region of India and Pakistan, as well as North China, irrigation has been a major contributor to increased grain output. More widely over the last 40 years, a massive increase in fertilizer use together with the increased availability of semi-dwarf varieties in developing countries has greatly increased yields per hectare.

World trade

The largest exporters of wheat in 2009 were, in order of exported quantities: United States, EU-27, Canada, Russian Federation, Australia, Ukraine and Kazakhstan. The largest importers of wheat in 2009 were, in order of imported quantities: Egypt, EU-27, Brazil, Indonesia, Algeria and Japan. EU-27 was on both export and import list, because EU countries such as Italy and

Spain imported wheat, while other EU-27 countries exported their harvest. The Black Sea region - which includes Kazakhstan, the Russian Federation and Ukraine - is amongst the most promising area for grain exporters.

2.3.2-Paddy

Paddy or rice (*Oryza* sp.) is one of the most cultivated grains in the world. It belongs to the family Poaceae and has two cultivated species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. Rice also plays an important role in certain religions and popular beliefs. Genetic evidence has shown that rice originates from a single domestication 8,200–13,500 years ago in the Pearl River valley region of China. There are many varieties of rice that differ in size, texture, colour and taste. Rice cultivation is well-suited to countries and regions with low labour costs and high rainfall, as it is labour-intensive to cultivate and requires ample water. However, rice can be grown practically anywhere, even on a steep hill or mountain area with the use of water-controlling terrace systems. Although its parent species are native to Asia and certain parts of Africa, centuries of trade and exportation have made it commonplace in many cultures worldwide.

Origin and domestication

There have been plenty of debates on the origins of the domesticated rice. Genetic evidence shows that all forms of Asian rice, both *indica* and *japonica*, spring from a single domestication that occurred 8,200–13,500 years ago in China of the wild rice *Oryza rufipogon*. A 2012 study, through a map of rice genome variation, indicated that the domestication of rice occurred in the Pearl River valley region of China based on the genetic evidence. From East Asia, rice was spread to South and Southeast Asia. Before this research, the commonly accepted view, based on archaeological evidence, is that rice was first domesticated in the region of the Yangtze River valley in China.

Cultivation and cultivars

While most rice is bred for crop quality and productivity, there are varieties selected for characteristics such as texture, smell, and firmness. There are four major categories of rice worldwide: indica, japonica, aromatic and glutinous. The different varieties of rice are not considered interchangeable, either in food preparation or agriculture, so as a result, each major variety is a completely separate market from other varieties. It is common for one variety of rice to rise in price while another one drops in price.

Rice can be grown in different environments, depending upon water availability. Generally, rice does not thrive in a waterlogged area, yet it can survive and grow herein and it can also survive flooding. The major types of rice are: i) Lowland, rainfed, which is drought prone, favours medium depth; waterlogged, submergence, and flood prone, ii) Lowland, irrigated, grown in both the wet season and the dry season, iii) Deep water or floating rice, iv) Coastal Wetland, and v) Upland rice, well known for its drought tolerance.

Rice cultivars also fall into groups according to environmental conditions, season of planting, and season of harvest, called ecotypes. Some major groups are the Japan-type (grown in Japan), "buly" and "tjereh" types (Indonesia); "aman" (main winter crop), "aus" ("aush", summer), and "boro" (spring) (Bengal and Assam). Cultivars exist that are adapted to deep flooding, and these are generally called "floating rice".

The largest collection of rice cultivars is at the International Rice Research Institute (IRRI) in the Philippines, with over 100,000 rice accessions held in the International Rice Genebank. The National Gene bank of India at ICAR-National Bureau of Plant Genetic Resources, New Delhi also holds over 100,000 accessions. Rice cultivars are often classified by their grain shapes and texture. Indian rice cultivars include long-grained and aromatic Basmati (grown in the North), long and medium-grained Patna rice, and in South India (Andhra Pradesh and Karnataka) short-grained Sona Masuri (also called as *Bangaru theegalu*). In the state of Tamil Nadu, the most prized cultivar is *ponni* which is primarily grown in the delta regions of the Kaveri River. Kaveri is also referred to as *ponni* in the South and the name reflects the geographic region where it is grown. In the Western Indian state of Maharashtra, a short grain variety called Ambemohar is very popular. This rice has a characteristic fragrance of Mango blossom.
Aromatic rice have definite aromas and flavours; the most noted cultivars are Thai fragrant rice, Basmati, Patna rice, Vietnamese fragrant rice, and a hybrid cultivar from America, sold under the trade name Texmati. Both Basmati and Texmati have a mild popcorn-like aroma and flavor. In Indonesia, there are also *red* and *black* cultivars.

Rice genome

Draft genomes for the two most common rice cultivars, *indica* and *japonica*, were published in April 2002. Rice was chosen as a model organism for the biology of grasses because of its relatively small genome (~430 megabase pairs). Rice was the first crop with a complete genome sequence.

Production

Rice is grown in about 160 million hectares area worldwide with total production of about 740 million tonnes. The average world farm yield for rice was 4.5 tonnes per hectare. Rice is mainly cultivated by small farmers in holdings of less than 1 ha. Rice is vital for the nutrition of much of the population in Asia, as well as in Latin America and the Caribbean and in Africa; it is central to the food security of over half the world population. Developing countries account for 95% of the total production, with China and India alone responsible for nearly half of the world output. The three largest producers of rice are China, India, and Indonesia. Among the six largest rice producers, the most productive farms for rice were in China producing about 7.0 tonnes per hectare.

Nutritional value

Rice is the staple food of over half the world's population. It is the predominant dietary energy source for several countries in Asia and the Pacific, in North and South America and countries in Africa. Rice provides 20% of the world’s dietary energy supply, while wheat supplies 19% and maize (corn) 5%. The nutrition value of rice varies based on a number of factors. It depends on the strain of rice, that is between white, brown, red, and black (or purple) varieties of rice - each prevalent in different parts of the world. It also depends on nutrient quality of the soil rice is grown in, whether and how the rice is polished or processed, the manner it is enriched, and how it is prepared before consumption. Highly coloured rice strains, such as black (purple) rice, derive their colour from anthocyanins and tocols. Scientific studies suggest that these colour pigments have antioxidant properties that may be useful to human health. In purple rice bran, hydrophilic antioxidants are in greater quantity and have higher free radical scavenging activity than lipophilic antioxidants. Anthocyanins and γ-tocols in purple rice are largely located in the inner portion of purple rice bran.

Rice is a good source of protein and a staple food in many parts of the world, but it is not a complete protein: it does not contain all of the essential amino acids in sufficient amounts for good health, and should be combined with other sources of protein, such as nuts, seeds, beans, fish, or meat.

Environment impact of rice cultivation

Rice cultivation on wetland rice fields is thought to be responsible for 11% of the anthropogenic methane emissions. Rice requires slightly more water to produce than other grains. Rice production uses almost a third of Earth’s fresh water. Methane is twenty times more potent a greenhouse gas than carbon dioxide. A 2010 study found that, as a result of rising temperatures and decreasing solar radiation during the later years of the 20th century, the rice yield growth rate has decreased in many parts of Asia, compared to what would have been observed had the temperature and solar radiation trends not occurred. The yield growth rate had fallen 10–20% at some locations.

“Golden rice”

Rice kernels do not contain vitamin A, so people who obtain most of their calories from rice are at risk of vitamin A deficiency. German and Swiss researchers have genetically engineered rice to produce beta-carotene, the precursor to vitamin A, in the rice kernel. The beta-carotene turns the processed (white) rice a "gold" colour, hence the name "golden rice." The beta-carotene is converted to vitamin A in humans who consume the rice. Although some rice strains produce beta-carotene in the hull, no non-genetically engineered strains have been found that produce beta-carotene in the kernel, despite the testing of thousands of strains. Additional efforts are being made to improve the quantity and quality of other nutrients in golden rice. The

International Rice Research Institute is currently further developing and evaluating Golden Rice as a potential new way to help address vitamin A deficiency.

2.3.3-Maize

Maize (or corn), ***Zea mays* L.**, is a cereal crop and is a member of the grass family Poaceae. Maize is grown around the world and is one of the globe's most widely used food staples. Maize varieties are directly used for food and animal feed or processed to make food and feed ingredients (such as high fructose corn syrup, corn starch and lysine) or industrial products such as ethanol and polylactic acid (PLA). The leafy stalk produces ears which contain the grain, which are seeds called kernels. The six major types of maize are dent, flint, pod, popcorn, flour, and sweet.

Origin and domestication

Most historians believe maize was domesticated in the Tehuacan Valley of Mexico. The Olmec and Mayans cultivated it in numerous varieties throughout Mesoamerica. Beginning about 2500 BC, the crop spread through much of the Americas. The region developed a trade network based on surplus and varieties of maize crops. After European contact with the Americas in the late 15th and early 16th centuries, explorers and traders carried maize back to Europe and introduced it to other countries. Maize spread to the rest of the world because of its ability to grow in diverse climates. Sugar-rich varieties called sweet corn are usually grown for human consumption as kernels, while field corn varieties are used for animal feed, various corn-based human food uses (including grinding into cornmeal or masa, pressing into corn oil, and fermentation and distillation into alcoholic beverages like bourbon whiskey), and as chemical feed stocks.

An influential 2002 study has demonstrated that all maize arose from a single domestication in southern Mexico about 9,000 years ago. The study also demonstrated that the oldest surviving maize types are those of the Mexican highlands. Later, maize spread from this region over the Americas along two major paths. This is consistent with a model based on the archaeological record suggesting that maize diversified in the highlands of Mexico before spreading to the lowlands.

Maize is the domesticated variant of teosinte. The two plants have dissimilar appearance, maize having a single tall stalk with multiple leaves and teosinte being a short, bushy plant. The difference between the two is largely controlled by differences in just two genes. Several theories had been proposed about the specific origin of maize in Mesoamerica. It is a direct domestication of a Mexican annual teosinte, *Zea mays* ssp. *parviglumis*, native to the Balsas River valley in south-eastern Mexico, with up to 12% of its genetic material obtained from *Zea mays* ssp. *mexicana* through introgression. The teosinte origin theory was proposed by the Russian botanist N.I. Vavilov in 1931 and the later American Nobel Prize-winner George Beadle in 1932. It is supported experimentally and by recent studies of the plants' genomes. Teosinte and maize are able to cross-breed and produce fertile offspring. A number of questions, however, still remain unanswered.

Different forms of maize

Many forms of maize are used for food, sometimes classified as various subspecies related to the amount of starch each has, Flour corn: *Zea mays* var. *amylacea;* Popcorn: *Zea mays* var. *Everta;* Dent corn : *Zea mays* var. *indentata;* Flint corn: *Zea mays* var. *indurate;* Sweet corn: *Zea mays* var. *saccharata* and *Zea mays* var. *rugosa;* Waxy corn: *Zea mays* var. *certain;* Amylomaize: *Zea mays;* Pod corn: *Zea mays* var. *tunicata*, and Striped maize: *Zea mays* var. *japonica.* This system has been replaced (though not entirely displaced) over the last 60 years by multivariable classifications based on ever more data. Agronomic data were supplemented by botanical traits for a robust initial classification, then genetic, cytological, protein and DNA evidence was added. Now, the categories are forms (little used), races, racial complexes, and recently branches.

Genetics

Maize is a diploid with 20 chromosomes (n=10). The combined length of the chromosomes is 1500 cM. Some of the maize chromosomes have what are known as "chromosomal knobs": highly repetitive heterochromatic domains that stain darkly. Individual knobs are polymorphic among strains of both maize and teosinte. Barbara McClintock used these knob markers to validate her transposon theory of "jumping genes", for which she won the 1983 Nobel Prize in Physiology or Medicine. Maize is still an important model organism for genetics and developmental biology today.

Primary sequencing of the maize genome was completed in 2008. On November 20, 2009, the consortium published results of its sequencing effort in *Science*. The genome, 85% of which is composed of transposons, was found to contain 32,540 genes (By comparison, the human genome contains about 2.9 billion bases and 26,000 genes). Much of the maize genome has been duplicated and reshuffled by helitrons-group of rolling circle transposons.

Plant breeding, cultivation and production

Maize is the most widely grown grain crop throughout the Americas, with 332 million metric tons grown annually in the United States alone. Approximately 40% of the crop-130 million tons-is used for corn ethanol. Genetically modified maize made up 85% of the maize planted in the United States in 2009.

Maize reproduces sexually each year. This randomly selects half the genes from a given plant to propagate to the next generation, meaning that desirable traits found in the crop (like high yield or good nutrition) can be lost in subsequent generations unless certain techniques are used. Since the 1940s the best strains of maize have been first-generation hybrids made from inbred strains that have been optimized for specific traits, such as yield, nutrition, drought, pest and disease tolerance. Both conventional cross-breeding and genetic modification have succeeded in increasing output and reducing the need for cropland, pesticides, water and fertilizer. CIMMYT, Mexico operates a conventional breeding program to provide optimized strains. The program began in the 1980s. Hybrid seeds are distributed in Africa by the Drought Tolerant Maize for Africa project.

Genetically modified (GM) maize is one of the 25 GM crops grown commercially. Grown since 1997 in the United States and Canada, 86% of the US maize crop was genetically modified in 2010 and 32% of the worldwide maize crop was GM in 2011. As of 2011, Herbicide-tolerant and insect-resistant maize varieties are grown in many countries across the world. In September 2000, up to $50 million worth of food products were recalled due to contamination with Starlink genetically modified corn, which had been approved only for animal consumption and had not been approved for human consumption, and was subsequently withdrawn from the market.

Maize is widely cultivated throughout the world; the United States produces 40% of the world's harvest. Other top producing countries include China, Brazil, Mexico, Indonesia, India, France and Argentina. Maize and cornmeal (ground dried maize) constitute a staple food in many regions of the world. Maize is central to Mexican food. Introduced into Africa by the Portuguese in the 16th century, maize has become Africa's most important staple food crop.

Uses

Maize meal is made into a thick porridge in many cultures. Maize meal is also used as a replacement for wheat flour, to make cornbread and other baked products. Popcorn consists of kernels of certain varieties that explode when heated, forming fluffy pieces that are eaten as a snack. Roasted dried maize ears with semi hardened kernels, coated with a seasoning mixture of fried chopped spring onions with salt added to the oil, is a popular snack food in Vietnam. An unleavened bread called *makki di roti* is a popular bread eaten in the Punjab region of India and Pakistan.

Nutritional value

Chicha and *chicha morada* (purple chicha) are drinks typically made from particular types of maize. The first one is fermented and alcoholic, the second is a soft drink commonly drunk in Peru. Corn flakes are a common breakfast cereal in North America and the United Kingdom, and found in many other countries all over the world. Maize is a major source of starch. Cornstarch (maize flour) is a major ingredient in home cooking and in many industrialized food products. Maize is also a major source of cooking oil (corn oil) and of maize gluten. Maize starch can be hydrolyzed and enzymatically treated to produce syrups, particularly high fructose corn syrup, a sweetener; and also fermented and distilled to produce grain alcohol.

In a 100 gram serving, maize kernels provide 86 calories and are a good source (10-19% of the Daily Value) of the B vitamins, thiamin, niacin, pantothenic acid (B5) and folate. In moderate amounts, they also supply dietary fibre and the essential minerals, magnesium and phosphorus whereas other nutrients are in low amounts. Maize is the subject of genetic engineering research to improve levels of carotenoids, such as provitamin A, beta-carotene.

Maize produces a greater quantity of biomass than other cereal plants, which is used for fodder. Digestibility and palatability are higher when ensiled and fermented, rather than dried.

2.3.4-Bajra

Pearl millet (***Pennisetum glaucum***) is the most widely produced millet worldwide and is cultivated extensively in Africa and India since pre-historic times.

Origin and domestication

The centre of diversity, and suggested area of domestication, for the crop is in the Sahel zone of West Africa. Recent archaeobotanical research has confirmed the presence of domesticated pearl millet on the Sahel zone of northern Mali between 2500 and 2000 BC. Cultivation subsequently spread and moved overseas to India. The earliest archaeological records in India date to around 2000 BC, and it spread rapidly through India reaching South India by 1500 BC, based on evidence from the site of Hallur. Cultivation also spread throughout eastern and southern Africa. Records exist for cultivation of pearl millet in the United States in the 1850s, and the crop was introduced into Brazil in the 1960s.

Cultivation, production and uses

Because pearl millet millets require little water and are highly drought resistant, they grow well in arid and semi arid regions of the world such as in countries surrounding the Sahara desert in Africa and in dry areas in India and Asia. Further, pearl millet is an attractive agricultural crop for farmers in these regions because under good conditions, it can yield two harvests per year and is resistant to pests and pathogens. In the Sudan region of Africa, dietary surveys show that millet consumption was the primary source of food calories, respectively yielding up to 70% of total daily energy.

Pearl millet is well adapted to growing areas characterized by drought, low soil fertility, and high temperature. It performs well in soils with high salinity or low pH. Because of its tolerance to difficult growing conditions, it can be grown in areas where other cereal crops, such as maize or wheat, would not survive. Today pearl millet is grown on over 260,000 km^2 of land worldwide. It accounts for approximately 50% of the total world production of millets.

India is the largest producer of pearl millet; Rajasthan is highest producing state in India. Pearl millet is an important food across the Sahel region of Africa. It is a main staple (along with sorghum) in a large region of northern Nigeria, Niger, Mali and Burkina Faso. In Nigeria it is usually grown as an intercrop with sorghum and cowpea, the different growth habits, growth period and drought vulnerability of the three crops maximising total productivity and minimising the risk of total crop failure. It is often ground into flour, rolled into large balls, parboiled, liquefied into a watery paste using fermented milk and then consumed as a beverage. This beverage called "fura" in Hausa is popular drink in northern Nigeria and southern Niger.

Recently more productive varieties of pearl millet have been introduced, enabling farmers to increase production considerably. To combat the problem of micronutrient malnutrition in Africa and Asia, a study of serving iron-biofortified pearl millets which is bred conventionally without genetic modification to a control group is proved to have higher level of iron absorbance by the group.

2.3.5- Jowar

Jowar (*Sorghum* spp.) is a coarse, upright growing grass that is used for both grain and forage production. Most species are native to Australia, with some extending to Africa, Asia, Mesoamerica, and certain islands in the Indian and Pacific Oceans. One species, *Sorghum bicolor,* is grown for grain, while many others are used as fodder plants, either intentionally cultivated or allowed to grow naturally, in pasture lands. The plants are cultivated in warm climates worldwide and naturalized in many places.

Origin and domestication

S. bicolour originated in north-eastern Africa, with domestication having taken place there around 5,000–8,000 years ago. The largest diversity of cultivated and wild sorghum is also found in this part of Africa. The secondary centre of origin of sorghum is the Indian Subcontinent, with evidence for early cereal cultivation dating back about 4,500 years.

Cultivation, production and uses

Grain sorghum is also called "milo" and is a major feed grain for cattle. Grain sorghum doesn't require a lot of water and can survive long, hot summers. It is a principal feed ingredient for both cattle and poultry, in northern India it is very common as a forage crop and fed to animals fresh or as silage or hay. Sweet sorghum is used to a limited extent in producing sorghum syrup and 'jaggery' (raw sugar) in India and has recently gained importance in ethanol production

Sorghum is ground, cracked, steam flaked, and/or roasted. It can be cooked like rice, made into porridge, malted for beer, baked into flatbreads and popped like popcorn. Sorghum originated in Egypt 4,000 years ago and today is Africa's second most important cereal. Africa now produces 20 million tons of sorghum per year, a third of the world total.

The leading producers of *Sorghum bicolor* in 2011 were Nigeria (12.6%), India (11.2%), Mexico (11.2%) and the United States (10.0%). Sorghum grows in a wide range of temperature, high altitudes, toxic soils and can recover growth after some drought. Sorghum is cultivated in many parts of the world today. In the past 50 years, the area planted with sorghum worldwide had increased 66%. In many parts of Asia and Africa, its grain is used to make flat breads that form the staple food of many cultures. The grains can also be popped in a similar fashion to popcorn.

The species can be used as a source for making ethanol fuel, and in some environments may be better than maize or sugarcane, as it can grow under harsher conditions. It typically has protein levels of around 9%, enabling dependent human populations to subsist on it in times of famine, in contrast to regions where maize has become the staple crop. It is also used for making a traditional corn broom. The reclaimed stalks of the sorghum plant are used to make a decorative millwork material marketed as Kirei board. Sweet sorghum syrup is known as molasses in some parts of the U.S., although it is not true molasses.

In India, where it is commonly called *jwaarie*, *jowar*, *jola*, or *jondhahlaa*, sorghum is one of the staple sources of nutrition. An Indian bread, *jowar roti* or *jolada rotti*, is prepared from this grain. In some countries, sweet sorghum stalks are used for producing biofuel by squeezing the juice and then fermenting it into ethanol. Texas A&M University in the United States is currently running trials to find the best varieties for ethanol production from sorghum leaves and stalks in the USA.

Nutritional value

Sorghum grain contains 11.3% protein, 3.3% fat and 56–73% starch. Its protein content is higher than corn and about equal to wheat. Its fat content is lower than corn but higher than wheat. It is relatively rich in iron, zinc, phosphorus and B-complex vitamins. Tannins, found particularly in red-grained types, contain antioxidants that protect against cell damage, a major cause of diseases and aging. The protein and starch in sorghum grain are more slowly digested than those from other cereals, and slower rates of digestibility are particularly beneficial for people with diabetes. Sorghum starch is gluten-free, making sorghum a good alternative to wheat flour for individuals suffering from celiac disease.

Plant breeding

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) , and national program partners in Asia and sub-Saharan Africa, assessed the ‘spillover’ potential of sorghum varieties and hybrids. This aimed to find out how successful these varieties were in areas outside those that they were originally bred for. It has often been argued that, in heterogeneous environments, returns on the investment in breeding new varieties will be low, because new cultivars will tend to perform well in only the locations that they were initially bred for. However, the study demonstrated that this was not the case. In fact, cultivars originating from collaborative national and international research can prove to be highly transferable across different environments.

Improved varieties occupy approximately 36% of Tanzania's sorghum area. They are widely popular, mainly for their early maturity (and thus drought tolerance) and high yield – 10–38% higher than local varieties. Adoption has been stimulated by interventions by ICRISAT and local partners to strengthen local seed systems and community-based seed production.

Genome

The genome of *Sorghum bicolor* was sequenced between 2005 and 2007.

2.4 CULTIVATION, PRODUCTION AND USES OF LEGUMES

2.4.1-Pigeon Pea

The pigeon pea (*Cajanus cajan*) is a perennial legume from the family Fabaceae. Since its domestication in South Asia at least 3,500 years ago, its seeds have become a common food grain in Asia, Africa, and Latin America. Pigeon peas, a popular vegetable in tropical countries, are healthy and versatile. Ripe pigeon peas are a common ingredient in dhal, an Indian split-pea soup. Immature pigeon pea seeds, also called green pigeon peas, are reputed as an old folk medicine remedy for liver and kidney ailments, according to Purdue University, but they offer real health benefits today. They are a nutrient-rich addition to rice or a variety of other foods and can supplement your diet with protein, fibre, vitamins and minerals.

Origin and domestication

The cultivation of the pigeon pea goes back at least 3,500 years. The centre of origin is the eastern part of peninsular India, including the state of Odisha, where the closest wild relatives (*Cajanus cajanifolia*) occur in tropical deciduous woodlands. Archaeological finds of pigeon pea include those from two Neolithic sites in Odisha, Gopalpur and Golbai Sassan dating between 3,400 and 3,000 years ago, and sites in South India, Sanganakallu and Tuljapur Garhi, also dating back to 3,400 years ago. From India it travelled to East Africa and West Africa. There, it was first encountered by Europeans, so it obtained the name Congo Pea. By means of the slave trade it came to the American continent, probably in the 17th century.

Cultivation

Today, pigeon peas are widely cultivated in all tropical and semitropical regions of both the Old and the New Worlds. Pigeon peas can be of a perennial variety, in which the crop can last three to five years (although the seed yield drops considerably after the first two years), or an annual variety more suitable for seed production.

Pigeon peas are an important legume crop of rainfed agriculture in the semiarid tropics. The Indian subcontinent, eastern Africa and Central America, in that order, are the world's three main pigeon pea-producing regions. The crop is cultivated on marginal land by resource-poor farmers, who commonly grow traditional medium- and long-duration (5–11 months) landraces. Short-duration pigeon peas (3–4 months) suitable for multiple cropping have recently been developed.

Pigeon peas are very drought-resistant, so can be grown in areas with less than 650 mm annual rainfall. With the maize crop failing three out of five years in drought-prone areas of Kenya, a consortium led by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) aimed to promote the pigeon pea as a drought-resistant, nutritious alternative crop. World production of pigeon peas is estimated at 4.3 million tons. About 82% of this is grown in India. These days it is the most essential ingredient of animal feed used in West Africa, especially in Nigeria, where it is also grown.

Uses

In India, split pigeon peas (*toor dal*) is one of the most popular pulses, being an important source of protein in a mostly vegetarian diet. In regions where it grows, fresh young pods are eaten as a vegetable in dishes such as *sambar*. In Ethiopia, not only the pods, but also the young shoots and leaves are cooked and eaten. In some places, such as the Caribbean coast of Colombia, Dominican Republic, Panama and Hawaii, pigeon peas are grown for canning and consumption.

Pigeon peas are in some areas an important crop for green manure, providing up to 90 kg nitrogen per hectare. The woody stems of pigeon peas can also be used as firewood, fencing and thatch.

Genome sequence

The pigeon pea is the first seed legume plant to have its complete genome sequenced. The sequencing was accomplished by a global research partnership, the International Initiative for Pigeonpea Genomics (IIPG), led by ICRISAT with partners such as BGI –Shenzhen (China), US research laboratories like University of Georgia, University of California-Davis, Cold Spring Harbour Laboratory, and National Centre for Genome Resources, European research institutes like the National University of Ireland Galway and also support from the CGIAR Generation Challenge Programme, US National Science Foundation and in-kind contribution from the collaborating research institutes. It is the first time that a Consultative Group on International Agricultural Research (CGIAR)-supported Centre such as ICRISAT led the genome sequencing of a food crop. In parallel, a group of 31 Indian scientists from the Indian Council of Agricultural Research also published its genome sequence.

Nutritional value

Pigeon peas contain high levels of protein and the important amino acids methionine, lysine, and tryptophan. Methionine+Cystine combination is the only limiting amino acid combination in pigeon pea. In contrast to the mature seeds, the immature seeds are generally lower in all nutritional values, however they contain a significant amount of vitamin C (39 mg per 100 g serving) and have a slightly higher fat content. Research has shown that the protein content of the immature seeds is of a higher quality.

2.4.2-Pea

The pea is most commonly the small spherical seed or the seed-pod of the pod fruit *Pisum sativum*. Each pod contains several peas. Pea pods are botanically fruit, since they contain seeds and developed from the ovary of a (pea) flower. Peas have a long history as multipurpose edible plants popular among chefs and even royalty. They are cool season green vegetables that grow in numerous climates. Peas are ideal for vegetable gardens as they are easy to grow and provide a nutritious ingredient for many recipes or as a simple stand alone dish.

Origin and domestication

The wild pea is restricted to the Mediterranean basin and the Near East. The earliest archaeological finds of peas date from the late neolithic era of current Greece, Syria, Turkey and Jordan. In Egypt, early finds date from *ca.* 4800–4400 BC in the Nile delta area, and from *ca.* 3800–3600 BC in Upper Egypt. The pea was also present in Georgia in the 5th millennium BC. Farther east, the finds are younger. Peas were present in Afghanistan *ca.* 2000 BC, in Harappa, Pakistan, and in northwest India in 2250 -1750 BC. In the second half of the 2nd millennium BC, this pulse crop appears in the Gangetic basin and Southern India.

Cultivation

A pea is a most commonly green, occasionally golden yellow, or infrequently purple pod-shaped vegetable, widely grown as a cool season vegetable crop. The seeds may be planted as soon as the soil temperature reaches 10 °C, with the plants growing best at temperatures of 13 to 18 °C. They do not thrive in the summer heat of warmer temperate and lowland tropical climates, but do grow well in cooler, high altitude, tropical areas. Many cultivars reach maturity about 60 days after planting. Peas have both low-growing and vining cultivars. The vining cultivars grow thin tendrils from leaves that coil around any available support and can climb to be 1–2 m high. A traditional approach to supporting climbing peas is to thrust branches pruned from trees or other woody plants upright into the soil, providing a lattice for the peas to climb. Branches used in this fashion are sometimes called pea brush. Metal fences, twine, or netting supported by a frame are used for the same purpose. In dense plantings, peas give each other some measure of mutual support. Pea plants can self-pollinate.

Uses

Peas have been a part of French and Asian cuisine for over 1,000 years. In India, fresh peas are used in various dishes such as *aloo matar* (curried potatoes with peas) or *matar paneer* (paneer cheese with peas), though they can be substituted with frozen peas as well. Peas are also eaten raw, as they are sweet when fresh off the bush. Split peas are also used to make *dhal*, particularly in Guyana, and Trinidad, where there is a significant population of Indians. In order to freeze and preserve peas, they must first be grown, picked, and shelled. Usually, the tenderer the peas are, the more likely the peas will be used in the final product. The frozen peas are then packaged and shipped out for retail.

Nutritional value

Peas are starchy, but high in fibre, protein, vitamin A, vitamin B6, vitamin C, vitamin K, phosphorus, magnesium, copper, iron, zinc and lutein. Dry weight is about one-quarter protein and one-quarter sugar. Pea seed peptide fractions have less ability to scavenge free radicals than glutathione, but greater ability to chelate metals and inhibit linoleic acid oxidation.

Varieties

There are many varieties (cultivars) of garden peas. *PMR* indicates some degree of powdery mildew resistance; *afila* types, also called semi-leafless, have clusters of tendrils instead of leaves. These are so called dwarf varieties which grow to an average height of about 1m. Extra dwarf are suitable for container growing, reaching only about 25 cm. Semi-tall reaches about 1.5m and tall grows to about 2m. Other variations of *P. sativum* include, *P. sativum* var. *macrocarpon* is commonly known as the snow pea, and *P. sativum* var. *macrocarpon* ser. cv. is known as the sugar or snap pea. Both of these are eaten whole before the pod reaches maturity and are hence also known as *mange-tout*, French for "eat all". The snow pea pod is eaten flat, while in sugar/snap peas, the pod becomes cylindrical, but is eaten while still crisp, before the seeds inside develop.

Peas in Science

In the mid-19th century, Austrian monk Gregor Mendel's observations of pea pods led to the principles of Mendelian genetics, the foundation of modern genetics. He ended up growing and examining about 28,000 pea plants in the course of his experiments. Mendel chose peas for his experiments because he could grow them easily, develop pure-bred strains, protect them from cross-pollination, and control their pollination. Mendel cross-bred tall & dwarf pea plants, green & yellow peas, purple & white flowers, wrinkled & smooth peas, and a few other traits. He then observed the resulting offsprings and came out with three famous laws, Law of Segregation, Law of Independent Assortment and Law of Dominance. Unwittingly, Mendel had solved a major problem with Charles Darwin's theory of evolution: how could new traits be preserved and not blended back into the population? But Darwin never learned about it. Mendel's work was published in an obscure Austrian journal and was not rediscovered until about 1900.

2.4.3-Green Gram

The moong bean, *Vigna radiata* (L.) Wilczek is a plant species in legume family and has been grown in India since ancient times. Native to the Indian subcontinent, it is still widely grown in Southeast Asia, Africa, South America and Australia. It is also cultivated in hot, dry regions in

Southern Europe and the Southern United States. It is used as an ingredient in both savoury and sweet dishes.

Origin and domestication

The moong bean was domesticated in India, where its progenitor (*Vigna radiata* subsp. *sublobata*) occurs wild. Archaeological evidence has turned up carbonized moong beans on many sites in India. Areas with early finds include the eastern zone of the Harappan civilization in Punjab and Haryana, where finds date back about 4500 years, and South India in the modern state of Karnataka where finds date back more than 4000 years. Some scholars therefore infer two separate domestications in the northwest and south of India. In South India there is evidence for evolution of larger-seeded moong beans 3500 to 3000 years ago. By about 3500 years ago moong beans were widely cultivated throughout India. Cultivated moong beans later spread from India to China and Southeast Asia.

Uses

Moong beans are commonly used in various cuisines across Asia. Whole cooked moong beans are generally prepared from dried beans by boiling until they are soft. Moong beans are light yellow in colour when their skins are removed. Moong bean paste can be made by dehulling, cooking, and pulverizing the beans to a dry paste. Although whole moong beans are also occasionally used in Indian cuisine, beans without skins are more commonly used; but in Kerala, whole moong beans are commonly boiled to make a dry preparation often served with rice gruel (*kanji*). Dehulled moong beans can also be used in a similar fashion as whole beans for the purpose of making sweet soups. Moong beans in some regional cuisines of India are stripped of their outer coats to make moong *dal*. In Tamil Nadu, Telangana and Andhra Pradesh, steamed whole beans are seasoned with spices and fresh grated coconut in a preparation called *sundal*. In south and north Indian states, moong beans are also eaten as pancakes. These are usually eaten for breakfast. This provides high quality protein that is rare in most Indian regional cuisines. *Pongal* or *kichdi* is another recipe that is made with rice and moong beans without skin. In Kerala, it is commonly used to make the *parippu* preparation in the Travancore region. It is also used, with coconut milk and jaggery, to make a type of *payasam*.

Moong bean sprouts are germinated by leaving them in water for four hours of daytime light and spending the rest of the day in the dark. Moong bean seeds are sprouted for fresh use or canned for shipment to restaurants. Sprouts are high in protein (21%–28%), calcium, phosphorus and certain vitamins. Because they are easily digested they replace scarce animal protein in human diets in tropical areas of the world. Because of their major use as sprouts, a high quality seed with excellent germination is required. If the moong bean seed does not meet sprouting standards it can be used as a livestock food with about 1.5 ton of moong bean being equivalent to 1.0 tons of soybean meal for protein content.

2.4.4-Black Gram

Black gram, also known as Urd bean, is a bean grown in Indian subcontinent. It is largely used to make dal from the whole or split, de-husked seeds.

Origin and domestication

Black gram originated in India where it has been in cultivation from ancient times and is one of the most highly prized pulses of India. It has also been introduced to other tropical areas mainly by Indian immigrants.

Cultivation, production and uses

It is very nutritious and is recommended for diabetics, as are other pulses. It is very popular in Punjabi cuisine of India and Pakistan where it is known as "maash". The coastal Andhra region in Andhra Pradesh is famous for black gram after paddy. The Guntur District ranks first in Andhra Pradesh for the production of black gram.

The beans are boiled and eaten whole or after splitting into dal; prepared like this it has an unusual mucilaginous texture. Ground into flour or paste, it is also extensively used in culinary preparation like dosa, idli, vada, and papad. When used this way, the white lentils are usually used with the black skin removed. It has been historically used as cementing agent along with other ingredients in the construction of several historic buildings. In medieval times, this bean was used in making crucibles impermeable.

Nutrition

Black gram is very nutritious as it contains high levels of protein (25g/100g), potassium (983 mg/100g), calcium (138 mg/100g), iron (7.57 mg/100g), niacin (1.447 mg/100g), Thiamine (0.273 mg/100g), and riboflavin (0.254 mg/100g). Black gram complements the essential amino acids provided in most cereals and plays an important role in the diets of the people of Nepal and India. Black gram has been shown to be useful in mitigating elevated cholesterol levels.

2.4.5-Rajmash

Rajmash (*Phaseolus vulgaris*), the common bean (also known as the field bean, French bean, garden bean or snap bean, etc.), is a herbaceous annual plant grown worldwide for its edible dry seed or unripe fruit that are both known as "beans". Its leaf is also occasionally used as a vegetable and the straw as fodder. Its botanical classification, along with other *Phaseolus* species, is as a member of the legume family *Fabaceae*, most of whose members acquire the nitrogen they require through an association with rhizobia, a species of nitrogen-fixing bacteria.

Origin and domestication

The wild *P. vulgaris* was native to the Americas and was domesticated separately in Mesoamerica and in the southern Andes region, giving the domesticated bean two gene pools which remain separate to this day. Along with squash and maize (corn), beans are one of the "Three Sisters" central to indigenous North American agriculture.

Description

The common bean is a highly variable species that has a long history of cultivation. All wild members of the species have a climbing habit, but many cultivars are classified as "bush beans" or "pole beans", depending on their style of growth. These include the kidney bean, the navy bean, the pinto bean, and the wax bean. The other major types of commercially grown bean are the runner bean (*Phaseolus coccineus*) and the broad bean (*Vicia faba*).

The common bean is a highly variable species with a long history. Bush varieties form erect bushes 20–60 cm (8–20 in) tall, while pole or running varieties form vines 2–3 m (7–10 ft) long. All varieties bear alternate, green or purple leaves, which are divided into three oval, smooth-edged leaflets, each 6–15 cm (2–6 in) long and 3–11 cm (1–4 in) wide. The white, pink, or purple flowers are about 1 cm long, and they give way to pods 8–20 cm (3–8 in) long and 1–1.5 cm wide. These may be green, yellow, black, or purple in colour, each containing 4–6 beans. The beans are smooth, plump, kidney-shaped, up to 1.5 cm long, range widely in colour, and are often mottled in two or more colours.

Dry beans: Similar to other beans, the common bean is high in starch, protein, and dietary fibre, and is an excellent source of iron, potassium, selenium, molybdenum, thiamine, vitamin B_6, and folate. Dry beans will keep indefinitely if stored in a cool, dry place, but as time passes, their nutritive value and flavour degrade and cooking times lengthen. Dried beans are almost always cooked by boiling, often after being soaked in water for several hours. Dry common beans take longer to cook than most pulses: cooking times vary from one to four hours, but are substantially reduced with pressure cooking. Dry beans may also be bought cooked and canned as refried beans, or whole with water, salt, and sometimes sugar.

Green beans and wax beans: The three commonly known types of green beans are: string or snap beans, which may be round or have a flat pod; stringless or French beans, which lack a tough, fibrous "string" running along the length of the pod; and runner beans, which belong to a separate species, *Phaseolus coccineus*. Green beans may have a purple rather than green pod, which changes to green when cooked. Wax beans are *P. vulgaris* beans that have a yellow or white pod. Wax bean cultivars are commonly grown; the plants are often of the bush form. Compared to dry beans, green and wax beans provide less starch and protein and more vitamin A and vitamin C. Green beans and wax beans are often steamed, boiled, stir-fried, or baked in casseroles.

Shelling beans: Shell, shelled, or shelling beans are beans removed from their pods before being cooked or dried. Common beans can be used as shell beans, but the term also refers to other species of beans whose pods are not typically eaten, such as lima beans, soybeans, peas, and faba beans. Fresh shell beans are nutritionally similar to dry beans, but are prepared more like a vegetable, often being steamed, fried, or made into soups.

Popping beans: The *nuña* is an Andean subspecies, *P. v.* subsp. *nunas* (formerly *P. vulgaris* Nuñas group), with round, multicolored seeds that resemble pigeon eggs. When cooked on high heat, the bean explodes, exposing the inner part, in the manner of popcorn and other puffed grains.

Varieties

Many well-known bean varieties belong to this species. Both bush and running (pole) varieties exist. The colours and shapes of pods and seeds vary over a wide range.

Production

Beans are grown in every continent except Antarctica. Brazil and India are the largest producers of dry beans, while China produces, by far, the largest quantity of green beans. Worldwide, 23 million tonnes of dry common beans and 17.1 million tonnes of green beans were grown in 2010.

2.4.6-Gram

Chickpea, also known as garbanzo bean, is a legume and belongs to the pea family. It originates from Turkey, Syria and Iran. Cultivation of chickpea started 7000 years BC. It was popular and widely consumed in the ancient Egypt, Greece and Rome. Chickpea is still one of the most widely cultivated and consumed crops in the world (especially in the poor communities in Africa and Asia). Chickpea grows on a well-drained soil in warm and arid areas that provide enough sun. It is sensitive to frost and heavy rainfall. Chickpea is prone to fungal diseases that can decrease harvest drastically. There are 43 species and numerous varieties of chickpea that are mainly cultivated as a source of food. Other than that, chickpea has application in textile industry and industry of dyes.

Origin and domestication

Chickpeas originated in the Middle East, the region of the world whose varied food cultures still heavily rely upon this high protein legume. The first record of chickpea being consumed dates back about seven thousand years. They were first cultivated around approximately 3000 BC. Their cultivation began in the Mediterranean basin and subsequently spread to India and Ethiopia. Chickpeas were grown by the ancient Egyptians, Greeks and Romans and were very popular among these cultures. During the 16th century, chickpeas were brought to other subtropical regions of the world by both Spanish and Portuguese explorers as well as Indians who emigrated to other countries. Today, the main commercial producers of chickpeas are India, Pakistan, Turkey, Ethiopia and Mexico.

Genome sequencing

Sequencing of the chickpea genome has been completed for 90 chickpea genotypes, including several wild species. A collaboration of 20 research organizations, led by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) identified more than 28,000 genes and several million genetic markers. Scientists expect this work will lead to the development of superior varieties. The new research will benefit the millions of developing country farmers who grow chickpea as a source of much needed income, as well as for its ability to add nitrogen to the soil in which it grows. Production is growing rapidly across the developing world, especially in West Asia where it has increased four-fold over the past 30 years. India is by far the world largest producer but is also the largest importer.

Chickpea types

The plant grows to between 20–50 cm (8–20 inches) high and has small feathery leaves on either side of the stem. Chickpeas are a type of pulse, with one seedpod containing two or three peas. It has white flowers with blue, violet or pink veins.

There are three main kinds of chickpea. *Desi* has small, darker seeds and a rough coat. It is grown mostly in India and other parts of the Indian subcontinent, as well as in Ethiopia, Mexico, and Iran. *Desi* means 'country' or 'local' in Hindustani; its other names include *Bengal gram* or *kala chana* ("black chickpea" in both Hindi and Urdu) or *chhola boot*. *Desi* is probably the earliest variety because it closely resembles seeds found both on archaeological sites and the wild plant ancestor *Cicer reticulatum* of domesticated chickpeas, which only grows in southeast Turkey, where it is believed to have originated. *Desi* chickpeas have a markedly higher fibre content than other varieties, and hence a very low glycemic index, which may make them suitable for people with blood sugar problems. The *desi* type is used to make *chana dal*, which is a split chickpea with the skin removed. Bombay chickpeas (*Bambai*) are also dark but slightly larger than *desi*. They too are popular in the Indian subcontinent.

Kabuli are lighter-coloured, larger and with a smoother coat, and are mainly grown in the Mediterranean, Southern Europe, Northern Africa, South America and Indian subcontinent. The name means "from Kabul" in Hindi and Urdu, and this variety was thought to come from Kabul, Afghanistan when it was introduced to India in the 18th century. An uncommon black chickpea, *cecineri*, is grown only in Apulia, in southeastern Italy. It is larger and darker than the *desi* variety.

Green chickpeas are common in the state of Maharastra, India. In Marathi, they are called *harbhara*. Chana dal is also called *harbara dal*. Tender, immature harbara roasted on coal before the skin is removed is called *hula* in Marathi.

Uses

Chickpeas are usually rapidly boiled for 10 minutes, and then simmered for a longer period. Dried chickpeas need a long cooking time (1–2 hours) but will easily fall apart when cooked longer. If soaked for 12–24 hours before use, cooking time can be shortened by around 30 minutes. Chickpeas can also be pressure cooked.

Mature chickpeas can be cooked and eaten cold in salads, cooked in stews, ground into a flour called gram flour (also known as chickpea flour and *besan* and used frequently in Indian cuisine), ground and shaped in balls and fried as falafel, or stirred into a batter and baked to make farinata or panelle.

Chickpes also has many popular uses in Iberian Peninsula, Portugal, Spain, Egypt, Arabian cuisine, Italy, American cuisines, Burma, Philippines, Mexico, etc.

Some varieties of chickpeas can be popped and eaten like popcorn. Chickpeas and Bengal grams are used to make curries and are one of the most popular vegetarian foods in the Indian subcontinent and in diaspora communities of many other countries. Popular dishes in Indian cuisine are made with chickpea flour, such as *mirchi bajji* and *mirapakaya bajji Telugu*. In India, as well as in the Levant, unripe chickpeas are often picked out of the pod and eaten as a raw snack and the leaves are eaten as a leaf vegetable in salads.

Nutritional value

Chickpeas serve as an energy and protein source not only in human nutrition but also as animal feed. Raw chickpeas have a lower trypsin and chymotrypsin inhibitor content than peas, common beans and soybeans. This leads to higher nutritional values and fewer digestive problems in non-ruminants. Non-ruminant diets can be completed with 200g/kg of raw chickpeas to promote egg production and growth of birds and pigs. Higher amounts can be used when chickpeas are previously treated with heat.

Chickpeas are a nutrient-dense food, providing rich content (> 20% of the Daily Value, DV) of protein, dietary fibre, folate, and certain dietary minerals such as iron and phosphorus. Thiamin, vitamin B6, magnesium and zinc contents are moderate, providing 10-16 percent of the DV. Chickpeas have a Protein Digestibility Corrected Amino Acid Score of about 76 percent, which is higher than fruits, vegetables, many other legumes, and cereals.

Compared to reference levels established by the United Nations Food and Agricultural Organization and World Health Organization, proteins in cooked and germinated chickpeas are rich in essential amino acids like lysine, isoleucine, tryptophan and total aromatic amino acids. A 100 g serving of cooked chickpeas provides 164 kilocalories. Carbohydrates make up 68 percent of calories, most of which (84 percent) is starch, followed by total sugars and dietary fibre. Lipid content is 3 percent, 75 percent of which is unsaturated fatty acids for which linoleic acid comprises 43 percent of total fat.

Production

Chickpeas are grown in the Mediterranean, western Asia, the Indian subcontinent, Australia, the Palouse region, and the Great Plains. India is the world leader in chickpea (Bengal gram) production, and produces some fifteen times as much as the second-largest producer, Australia. Other key producers are Pakistan, Turkey, Burma, Ethiopia and Iran.

2.4.7-Lentil

The lentil (*Lens culinaris*) is an edible pulse of the legume family, known for its lens-shaped seeds. It is about 40 cm tall, and the seeds grow in pods, usually with two seeds in each.

Origin and domestication

Lentils have been part of the human diet since aceramic (before pottery) Neolithic times, being one of the first crops domesticated in the Near East. Archeological evidence shows they were eaten 9,500 to 13,000 years ago.

Description

The colours of lentil seed range from yellow to red-orange to green, brown and black. Lentils also vary in size, and are sold in many forms, with or without the skins, whole or split.

The seeds require a cooking time of 10 to 40 minutes, depending on the variety-shorter for small varieties with the husk removed, such as the common red lentil- and have a distinctive, earthy flavor. Lentil recipes are used throughout South Asia, the Mediterranean regions and West Asia. They are frequently combined with rice, which has a similar cooking time. Rice and lentils are cooked together in *khichdi*, a popular dish in the Indian subcontinent (India and Pakistan); a similar dish, *kushari*, made in Egypt, is considered one of two national dishes. Lentils are used to prepare an inexpensive and nutritious soup all over Europe and North and South America, sometimes combined with some form of chicken or pork.

Dried lentils can also be sprouted by soaking in water for one day and keeping moist for several days, which changes their nutrition profile. Lentils with husk remain whole with moderate cooking; lentils without husk tend to disintegrate into a thick purée, which leads to quite different dishes.

Nutritional value

In a 100 g serving, raw lentils provide 353 calories and a rich source of numerous essential nutrients, particularly dietary fibre and protein supplying 122% and 52% of the Daily Value

(DV), respectively, (table). Micronutrients in high content include folate (120% DV), thiamine (76% DV), phosphorus (64% DV) and iron (58% DV).

With 26% of total food content from protein, lentils have the third-highest level of protein, by weight, of any legume or nut, after soybeans and hemp. Red (or pink) lentils contain a lower concentration of fibre than green lentils (11% versus 31%).The low levels of readily digestible starch (5%), and high levels of slowly digested starch (30%), make lentils of potential value to people with diabetes. The remaining 65% of the starch is a resistant starch classified as RS1, as a high-content resistant starch, which is 32% amylose. A minimum of 10% in starch from lentils escapes digestion and absorption in the small intestine (therefore called "resistant starch").

Lentils also have anti-nutrient factors, such as trypsin inhibitors and a relatively high phytate content. Trypsin is an enzyme involved in digestion, and phytates reduce the bioavailability of dietary minerals. The phytates can be reduced by soaking the lentils in warm water overnight.

Production

Lentils are relatively tolerant to drought, and are grown throughout the world. FAOSTAT reported that the world production of lentils for calendar year 2013 was 4,975,621 metric tons, primarily coming from Canada, India and Turkey. About a quarter of the worldwide production of lentils is from India, most of which is consumed in the domestic market. Canada is the largest export producer of lentils in the world. The Palouse region of eastern Washington and the Idaho panhandle, with its commercial centre at Pullman, Washington, constitute the most important lentil-producing region in the United States.

2.5 SUMMARY

Wheat, paddy (rice) and maize are the three major staple food crops globally. Rice is the main grain crop of India. India ranks second in the world in production of rice. About 34% of the total cultivated area of the nation is under rice cultivation. Rice is cultivated in areas having annual average rainfall of 125 cm. Major rice cultivating areas are north eastern India, eastern and western coastal regions. West Bengal, Punjab and Uttar Pradesh are the major rice producing states. Wheat is the second major crop in India. Wheat is cultivated in areas with mean annual rainfall of 75 cm and fertile soil. Wheat has got an important role in 'Green Revolution'. The highest quantity of wheat in the country is in Uttar Pradesh, 35 % of wheat is produced only in Uttar Pradesh. Punjab and Haryana are the states where production of wheat is on a large scale. Maize is an important crop of rainy season. Maize is cultivated in different areas and in different climates but it is suitable where temperature is 35° C and rainfall is 75 cm. It is cultivated in hilly areas-of Jammu and Kashmir and Himachal Pradesh. Maize is cultivated throughout our country but it is cultivated more in Punjab, U.P., Bihar, M.P. and Rajasthan.

Among millets, pearl millet (bajra) and sorghum (jowar) are the two important crops grown globally. Pearl millet is the most widely grown type of millet. It has been grown in Africa and the Indian subcontinent since prehistoric times. Jowar is grown where the climate is hot and dry. In India, it is cultivated in Maharashtra, Karnataka, Andhra Pradesh, and Tamil Nadu.

Legumes are important source of human food - next to the cereals. The term pulse is used for the seeds of leguminous plants. Legumes supply proteins and form chief source in vegetarian food. Leguminous plants fix nitrogen in root nodules - produced with the help of nitrogen fixing bacteria. Seeds, pods, leaves and the shoots also contain a high proportion of protein e.g. pigeonpea, black gram, green gram, the major legumes of Indian origin.

2.6 GLOSSARY

Aleurone: (Aleurone layer). The outermost cell layer of the endosperm, usually only one cell thick in wheat and the only endosperm tissue alive at maturity. The cells of this layer are responsible for the de-novo synthesis of enzymes needed at germination.

Caryopsis: The fruit, of grasses, in which the ripened ovary wall, the pericarp, is fused to the seed coats, the testa, at maturity.

Cereals: are grasses (members of the monocot family Poaceae, also known as Gramineae) cultivated for the edible components of their grain composed of the endosperm, germ, and bran.

Diploid: with two full sets of chromosomes in the nucleus of a cell; having two complements of haploid chromosomes, that are the two complete sets of chromosomes, one from each of the parental gamete. This is expressed symbolically as 2n, where n = the gamete number of chromosomes.

Aromatic Rice: Brown or white rice with a natural aroma and flavor similar to that of roasted nuts or popcorn. Various types grown; cooks dry and separate or moist and tender.

Basmati rice: A very slender, long-grain, highly aromatic rice grown in India and Pakistan; it is aged for a year after harvesting to develop full flavor. Available in brown and white

Brown Rice: Kernels of rice from which only the hull has been removed. The light brown color is caused by the presence of bran layers, which are rich in minerals and vitamins. Cooked brown rice has a slightly chewy texture and a nut-like flavor.

Rice Bran: The outer layer on brown rice and an excellent source of thiamin, niacin, vitamin B-6, iron, phosphorus, magnesium, potassium and fibre.

Texmati: A registered trademark brand of aromatic rice grown in the United States.

Transgenic: An experimentally-produced organism whose DNA includes genetic material that has been introduced by scientists.

Transposon: A transposon is a mobile segment of DNA that serves as an agent of genetic change in maize.

Millets: Millets are a group of highly variable small-seeded grasses, widely grown around the world as cereal crops or grains for fodder and human food. Millets are important crops in the semiarid tropics of Asia and Africa (especially in India, Nigeria, and Niger), with 97% of millet production in developing countries. The crop is favoured due to its productivity and short growing season under dry, high-temperature conditions.

Legumes: A **legume** is a plant in the family Fabaceae, or the fruit or seed of such a plant. Legumes are grown agriculturally, primarily for their food grain seed (example beans and lentils, or generally pulse), for livestock forage and silage, and as soil-enhancing green manure. Legumes are notable in that most of them have symbiotic nitrogen-fixing bacteria in structures called root nodules. Well-known legumes include pigeon pea, peas, beans, lentils, peanuts, etc.

Pulse: A pulse, sometimes called a "grain legume", is an annual leguminous crop yielding from one to twelve seeds of variable size, shape, and colour within a pod. Pulses are used as food for humans and other animals. Included in the pulses are: dry beans like pinto beans, kidney beans and navy beans; dry peas; lentils; and others.

2.7 SELF ASSESSMENT QUESTIONS

2.7.1 Short answer type Questions

1. The importance of cereal, millet and legume crops.
2. The cereal, millet and legume crops domesticated or originated in Indian sub-continent.
3. The impact of cereal, millet and legume crops on the global and Indian economy.
4. Important cereal, millet and legume crops and the regions or the state in India each one is grown.
5. The staple food of north Indian people.
6. The health benefits of millets.
7. Different types of common bean.
8. Different kinds of chick peas. Which chick pea type predominantly grown in India?

2.7.2 Multiple choice questions:

1. Which of the following wheats have the highest gluten content and are used for making bread, rolls and all-purpose flour-

(a) Soft red winter (b) Soft white wheat
(c) Hard white (d) Hard red spring

2. Genes for the 'dwarfing' trait, first used by-

(a) Indian scientists (b) Japanese scientists
(c) Mexican scientists (d) Canadian scientists

3. Einkorn wheat (*T. monococcum*) is diploid (AA) with two complements of-

(a) 7 chromosomes (b) 14 chromosomes
(c) 10 chromosomes (d) 21 chromosomes

4. Tetraploid purple wheats grown in the highlands of Ethiopia are rich in antioxidants
(a) Starch (b) Antioxidants
(c) Protein (d) Vitamin A

5. Genetic evidence has shown that the Asian rice originates in the
(a) NEH Region of India (b) Jeypore tract of Odisha
(c) NW Himalayas of India (d) Pearl River valley region of China

6. The genetically engineered “golden rice” is a rich source of-
(a) Starch (b) Protein
(c) Vitamin A (d) Antioxidant

7. An aromatic cultivar of rice from America is sold under the trade name
(a) Texmati (b) Basmati
(c) Kalanamak (d) Sona Msuri

8. The transposon theory of "jumping genes"is related to-
(a) Wheat (b) Maize
(c) Rice (d) Jowar

9. Which among the followings are the world top producers of jowar (*Sorghum bicolor)*-
(a) Mexico (b) USA
(c) Nigeria (d) India

10. The highest pearl millet producing state in India is-
(a) Madhya Pradesh (b) Gujarat
(c) Rajasthan (d) Andhra Pradesh

11. The centre of origin of pigeon pea is-
(a) India (b) China
(c) South Africa (d) Ethiopia

12. The legume crop Gregor J. Mendel chose for his experiments is-
(a) Common bean (b) Chickpea
(c) Pigeon pea (d) Pea

13. An international crop research institute (IARC) in India that works on sorghum, bajra, chickpea, pigeon pea and groundnut is
(a) ICRISAT (b) IRRI
(c) CIMMYT (d) CIAT

14. The legume crop originated and domesticated in Indian sub-continent is?
(a) Mung bean (b) Chickpea
(c) Lentil (d) Common bean

15. The world leader in chickpea production is-
(a) Australia (b) India
(c) Turkey (d) Pakistan

2.7.2 Answer Key: 1-(d), 2-(b), 3-(a), 4-(b), 5-(d), 6-(c), 7-(a), 8-(b), 9-(c), 10-(c), 11-(a), 12-(d), 13-(a), 14-(a), 15-(b)

2.8 REFERENCES

- *Willcox, T.K and Willcox, G (2006). "How fast was wild wheat domesticated?" Science 311 (5769): 1886. doi:10.1126/science.1124635. PMID 16574859.*
- Feldman, Moshe and Kislev, Mordechai E., Domestication of emmer wheat and evolution of free-threshing tetraploid wheat in "A Century of Wheat Research-From Wild Emmer Discovery to Genome Analysis", Published Online: 3 November 2008.
- Moshe Feldman & Mordechai E. Kislev (2007). Domestication of emmer wheat and evolution of free-threshing tetraploid wheat. Israel Journal of Plant Sciences, 55:207 – 221. **DOI:**10.1560/IJPS.55.3-4.207.
- Hogan, M.C. (2013) Wheat. Encyclopedia of Earth. National Council of Science and the Environment. ed. Lakhdar Boukerrou.
- Heun, MR et al. (1997). "Site of Einkorn Wheat Domestication Identified by DNA Fingerprinting". Science 278: 1312–4. doi:10.1126/science.278.5341.1312.
- Ozkan, H; Brandolini, A; Schäfer-Pregl, R; Salamini, F (2002). "AFLP analysis of a collection of tetraploid wheats indicates the origin of emmer and hard wheat domestication in southeast Turkey". Molecular Biology and Evolution 19 (10): 1797–801. doi:10.1093/oxfordjournals. molbev.a004002. PMID 12270906.
- Grundas, S.T. (2003) Wheat: The Crop, in Encyclopedia of Food Sciences and Nutrition p6130; Elsevier Science Ltd.
- Brenchley, R. et al. (2012). Analysis of the bread wheat genome using whole-genome shotgun equencing, Nature 491:705–710. doi:10.1038/nature11650.
- Bajaj, Y. P. S. (1990) Wheat. Springer. pp. 161-63. ISBN 3-540-51809-6.
- Nevo, Eviatar & A. B. Korol & A. Beiles & T. Fahima. (2002) Evolution of Wild Emmer and Wheat Improvement: Population Genetics, Genetic Resources, and Genome.... Springer. p. 8.

- Qin Liu et al. (2010). "Comparison of Antioxidant Activities of Different Colored Wheat Grains and Analysis of Phenolic Compounds". Journal of Agricultural and Food Chemistry 58 (16): 9235–9241. doi:10.1021/jf101700s.
- "Production of Wheat by countries". UN Food & Agriculture Organization (FAO). 2011. Retrieved 26 January 2015.
- "FAOSTAT: Production-Crops, 2013 data". Food and Agriculture Organization of the United Nations. 2013.
- Hogan, C. M. (2013) Wheat. Encyclopedia of Earth, National Council for Science and the Environment, Washington DC ed. P. Saundry.
- Molina, J.; Sikora, M.; Garud, N.; Flowers, J. M.; Rubinstein, S.; Reynolds, A.; Huang, P.; Jackson, S.; Schaal, B. A.; Bustamante, C. D.; Boyko, A. R.; Purugganan, M. D. (2011). "Molecular evidence for a single evolutionary origin of domesticated rice". *Proceedings of the National Academy of Sciences* 108 (20): 8351. doi:10.1073/pnas.1104686108.
- Huang, Xuehui; Kurata, Nori; Wei, Xinghua; Wang, Zi-Xuan; Wang, Ahong; Zhao, Qiang; Zhao, Yan; Liu, Kunyan et al. (2012). "A map of rice genome variation reveals the origin of cultivated rice". *Nature* 490 (7421): 497–501.
- Bibcode: 2012Nature.490..497H. doi:10.1038/nature11532. PMID 23034647.
- International Rice Research Institute *The Rice Plant and How it Grows* at the Wayback Machine (archived January 6, 2009). knowledgebank.irri.org.
- Juliano, Bienvenido O. (1993). "Rice in human nutrition". Food and Agricultural Organization of the United Nations.
- Vaughan, DA; Lu, B; Tomooka, N (2008). "The evolving story of rice evolution". *Plant Science* 174 (4): 394–408. doi:10.1016/j.plantsci.2008.01.016.
- MacNeish R. S. and Libby J. eds. (1995) *Origins of Rice Agriculture*. Publications in Anthropology No. 13.
- Molina, J.; Sikora, M.; Garud, N.; Flowers, J.M.; Rubinstein, S.; Reynolds, A.; Huang, P.; Jackson, S.; Schaal, B.A.; Bustamante, C.D.; Boyko, A.R.; Purugganan, M.D. (2011). "Molecular evidence for a single evolutionary origin of domesticated rice". *Proceedings of the National Academy of Sciences* 108 (20): 8351–8356. doi:10.1073/pnas.1104686108.
- National Research Council (1996). "African Rice". *Lost Crops of Africa: Volume I: Grains*. Lost Crops of Africa 1. National Academies Press. ISBN 978-0-309-04990-0. Retrieved July 18, 2008.
- Carney, Judith Ann (2001). *Black rice: the African origins of rice cultivation in the Americas*. Cambridge: Harvard University Press. ISBN 0-674-00452-3.
- fao.org (FAOSTAT). "Countries by commodity (Rice, paddy)". Retrieved February 11, 2014.
- "FAOSTAT: Production-Crops, 2012 data". Food and Agriculture Organization of the United Nations. 2014.
- "System of Rice Intensification". Cornell University. 2011.

- FAO (FAOSTAT). "Food Balance Sheets > Commodity Balances > Crops Primary Equivalent". Retrieved August 17, 2012.
- "How better rice could save lives: A second green revolution – The Economist". *The Economist*. Retrieved October 6, 2014.
- Neue Heinz-Ulrich (1993). "Methane emission from rice fields: Wetland rice fields may make a major contribution to global warming". *BioScience* 43 (7): 466–73. doi:10.2307/1311906. JSTOR 1311906.
- "World Greenhouse Gas Emissions in 2005". World Resources Institute. Archived from the original on October 2, 2013.
- The International Rice Genebank – conserving rice. IRRI.org Archived January 1, 1970 at the Wayback Machine
- Jackson MT (1997). "Conservation of rice genetic resources: the role of the International Rice Genebank at IRRI". *Plant Mol. Biol.* 35 (1–2): 61–7. doi:10.1023/A:1005709332130. PMID 9291960.
- Gillis, Justing (August 11, 2005). "Rice Genome Fully Mapped". *Washington Post*.
- International Rice Research Institute: Golden Rice
- Grobman, Alexander (1961). *Races of Maize in Peru*.
- Paliwal, R. L (2000). *Tropical maize: Improvement and production*. ISBN 9789251044575.
- Schnable, P. S.; Ware, D.; Fulton, R. S. et al. (2009). "The B73 Maize Genome: Complexity, Diversity, and Dynamics". *Science* 326 (5956): 1112–5. doi:10.1126/science.1178534. PMID 19965430.
- Doebley, John F. (2004). "The genetics of maize evolution" (PDF). *Annual Review of Genetics* 38: 37–59. doi:10.1146/annurev.genet.38.072902.092425. PMID 15568971.
- Ranere, Anthony J.; Piperno, Dolores R.; Holst, Irene et al. (2009). "The cultural and chronological context of early Holocene maize and squash domestication in the Central Balsas River Valley, Mexico" (PDF). *Proceedings of the National Academy of Sciences* 106 (13): 5014–5018. doi:10.1073/pnas.0812590106. PMC 2664064. PMID 19307573.
- Matsuoka, Y.; Vigouroux, Y; Goodman, MM et al. (2002). "A single domestication for maize shown by multilocus microsatellite genotyping". *Proceedings of the National Academy of Sciences* 99 (9): 6080–4. doi:10.1073/pnas.052125199. PMC 122905. PMID 11983901.
- "FAOSTAT". Food and Agriculture Organization of the United Nations. Retrieved August 5, 2014.
- "The origins of maize: the puzzle of pellagra". *EUFIC > Nutrition > Understanding Food*. The European Food Information Council. December 2001. Retrieved September 14, 2006.
- Manning, Katie, Ruth Pelling, Tom Higham, Jean-Luc Schwenniger and Dorian Q Fuller (2010) 4500-year old domesticated pearl millet (*Pennisetum glaucum*) from the Tilemsi Valley, Mali: new insights into an alternative cereal domestication pathway. Journal of Archaeological Science 38 (2): 312-322

- Fuller, D.Q. (2003). African crops in prehistoric South Asia: a critical review. in Neumann,K., Butler,A., Kahlheber,S. (ed.) Food, Fuel and Fields. Progress in Africa Archaeobotany. Africa Praehistorica 15 series. Cologne: Heinrich-Barth-Institut, 239-271.
- Millet. Consultative Group on International Agricultural Research.
- Board on Science and Technology for International Development; Office of International Affairs; National Research Council (1996-02-14). "Pearl Millet: Subsistence Types". *Lost Crops of Africa: Volume I: Grains*. Lost Crops of Africa 1. National Academies Press. p. 108. ISBN 978-0-309-04990-0. Retrieved 2007-11-07.
- Munyaradzi, Makoni (29 August 2013). "Biofortified pearl millet 'can combat iron deficiency'". *SciDev Net*. Retrieved 29 August 2013.
- Mutegi, Evans; Fabrice Sagnard, Moses Muraya, Ben Kanyenji, Bernard Rono, Caroline Mwongera, Charles Marangu, Joseph Kamau, Heiko Parzies, Santie de Villiers, Kassa Semagn, Pierre Traoré, Maryke Labuschagne (2010-02-01). "Ecogeographical distribution of wild, weedy and cultivated *Sorghum bicolor* (L.) Moench in Kenya: implications for conservation and crop-to-wild gene flow". *Genetic Resources and Crop Evolution* 57 (2): 243–253. doi:10.1007/s10722-009-9466-7.
- Sorghum, U.S. Grains Council.
- Cyanide (prussic acid) and nitrate in sorghum crops - managing the risks. Primary industries and fisheries. Queensland Government.
- Watson, Andrew M. *Agricultural Innovation in the Early Islamic World: The Diffusion of Crops and Farming Techniques, 700–1100*. Cambridge: Cambridge University Press, 1983. ISBN 0-521-24711-X.
- Van der Maeson, L. J. G. (1995). Pigeonpea Cajanus cajan, pp. 251–5 in Smartt, J. and Simmonds, N. W. (eds.), Evolution of Crop Plants. Essex: Longman.
- Fuller, D. Q.; Harvey, E. L. (2006). "The archaeobotany of Indian pulses: Identification, processing and evidence for cultivation". *Environmental Archaeology* 11 (2): 219. doi:10.1179/174963106x123232.
- *Pigeonpea in Eastern and Southern Africa* http://exploreit.icrisat.org/page/eastern_and_southern_africa/887/329. ICRISAT Posted 10 October 2012. Downloaded 26 January 2014.
- "Effect of Sprouting on invitro digestibility of some locally consumed leguminous seeds". Journal of Applied Sciences and Environmental Management. Vol. 10, Num. 3, 2006, pp. 55-58
- "ICRISAT-led global team cracks pigeonpea genome". Retrieved 2014-12-21.
- "Draft genome sequence of pigeonpea (*Cajanus cajan*), an orphan legume crop of resource-poor farmers". Retrieved 2014-12-21.
- "The first draft of the pigeonpea genome sequence". Retrieved 2014-12-21.
- "Nutrition Facts and Analysis for Pigeon peas (red gram), mature seeds, raw"

- Bressani R, Gómez-Brenes RA, Elías LG.; Hobart (1986). "Nutritional quality of pigeon pea protein, immature and ripe, and its supplementary value for cereals". *Arch Latinoam Nutr.* 36 (1): 108–16. PMID 363219.
- Peas have been found in the Neolithic site of Abeurador in the south of France (Toussaint-Samat).
- Bianchini, F.; Corbetta, F. (1976), *The Complete Book of Fruits and Vegetables*, New York: Crown, p. 40, ISBN 978-0-517-52033-8
- "How frozen vegetable is made - production process, making, used, processing, product, industry, machine". *madehow.com*.
- Jegtvig, Shereen (July 17, 2007). "Peas". *Nutrition*. About.com. Retrieved 2011-01-28.
- Pownall TL, Udenigwe CC, Aluko RE (2010). "Amino acid composition and antioxidant properties of pea seed (Pisum sativum L.) enzymatic protein hydrolysate fractions". *Journal of Agricultural and Food Chemistry* 58 (8): 4712–4718. doi:10.1021/jf904456r. PMID 20359226.
- "Peas-Western Oregon, Commercial Vegetable Production Guides". Oregon State University.
- Watson, Terumi. "UT Garden's Plant of the Month - Tom Thumb Pea". University of Tennessee. Retrieved February 28, 2015.
- "How to tell the difference between mungo and mung beans".
- "Mung bean | Define Mung bean at Dictionary.com". Dictionary.reference.com. Retrieved 2012-08-22.
- Tomooka, N.; Vaughan, D. A.; Moss, H.; Mixted, N. (2003). *The Asian Vigna: genus Vigna subgenus Ceratotropis genetic resources*. New York: Kluwer.
- Fuller, D. Q. (2007). "Contrasting patterns in crop domestication and domestication rates: recent archaeobotanical insights from the Old World". *Annals of Botany* 100 (5): 903–924. doi:10.1093/aob/mcm048. PMC 2759199. PMID 17495986.
- Fuller, D. Q.; Harvey, E. (2006). "The archaeobotany of Indian Pulses: identification, processing and evidence for cultivation". *Environmental Archaeology* 11 (2): 219–246. doi:10.1179/174963106x123232.
- Castillo, Cristina; Fuller, Dorian Q. (2010). "Still too fragmentary and dependent upon chance? Advances in the study of early Southeast Asian archaeobotany". In Bellina, B.; Bacus, E. A.; Pryce, O. et al. *50 Years of Archaeology in Southeast Asia: Essays in Honour of Ian Glover*. Bangkok/ London: River Books. pp. 91–111. ISBN 9786167339023.
- *Walshaw, S. C. (*2010). "Converting to rice: urbanization, islamization and crops on Pemba, AD 700-1500". *World Archaeology* 42: 137–154. doi:10.1080/00438240903430399.
- "Post Harvest Profile of Black Gram" (PDF). Government of India, Ministry of Agriculture. 2006.
- "Mungo beans, mature seeds, raw". *USDA National Nutrient Database for Standard Reference*. US Department of Agriculture.

- Menon, P. V.; Kurup, P. A. (1976). "Dietary fibre and cholesterol metabolism: Effect of fibre rich polysaccharide from blackgram (Phaseolus mungo) on cholesterol metabolism in rats fed normal and atherogenic diet". *Biomedicine / [publiee pour l'A.A.I.C.I.G.]* 24 (4): 248–53. PMID 990375.
- Indira, M.; Kurup, P.A. (September 2013). "Black Gram: A Hypolipidemic Pulse" (PDF). *Natural Product Radiance* 2 (5).
- Vijaya J. Deshpande. "Musavijnana or the ancient science of crucibles" (PDF). Indian National Science Academy.
- Gentry, Howard Scott (1969). "Origin of the Common Bean, *Phaseolus vulgaris*". *Economic Botany* (New York: New York Botanical Garden Press) 23 (1): 55–69. doi:10.1007/BF02862972. JSTOR 4253014.
- "*Phaseolus vulgaris* L.". Agricultural Research Service, United States Department of Agriculture. August 19, 2010. Retrieved September 22, 2013.
- Paul Gepts (December 1998). "Origin and evolution of common bean: past events and recent trends" (PDF). *HortScience* 33 (7): 1124–1130.
- "Kidney Beans". The world's healthiest foods. Retrieved 2007-11-05.
- Choi HK, Atkinson K, Karlson EW, Willett W, Curhan G (March 2004). "Purine-rich foods, dairy and protein intake, and the risk of gout in men". *N. Engl. J. Med.* 350 (11): 1093–103. doi:10.1056/NEJMoa035700. PMID 15014182.
- Zohary, Daniel and Hopf, Maria, *Domestication of Plants in the Old World* (third edition), Oxford University Press, 2000, p 110
- Nicholas Culpeper. *Chick-Pease, or Cicers*. *The Complete Herbal (1652, originally titled The English Physitian)*.
- Bampidis, V.A.; Christodoulou, V. (2011). "Chickpeas (Cicer arietinum L.) in animal nutrition: A review". *Animal Feed Science and Technology* 168: 1–20. doi:10.1016/j.anifeedsci.2011.04.098.
- El-Adawy, T.A. (2002). "Nutritional composition and antinutritional factors of chickpeas (Cicer arietinum L.) undergoing different cooking methods and germination". *Plant Foods for Human Nutrition* 57 (1): 83–97. PMID 11855623.
- Jukanti AK, Gaur PM, Gowda CL, Chibbar RN (2012). "Nutritional quality and health benefits of chickpea (Cicer arietinum L.): a review". *Br J Nutr* 108 (Suppl 1): S11–26. doi:10.1017/S0007114512000797. PMID 22916806.
- Khatoon N, Prakash J (2004). "Nutritional quality of microwave-cooked and pressure-cooked legumes". *Int J Food Sci Nutr* 55 (6): 441–8. doi:10.1080/09637480400009102. PMID 15762308.
- Milán-Carrillo J, Valdéz-Alarcón C, Gutiérrez-Dorado R, Cárdenas-Valenzuela OG, Mora-Escobedo R, Garzón-Tiznado JA, Reyes-Moreno C (2007). "Nutritional properties of quality protein maize and chickpea extruded based weaning food". *Plant Foods Hum Nutr* 62 (1): 31–7. doi:10.1007/s11130-006-0039-z. PMID 17243010.

- Ibrikci, H.; Knewtson, S.J.B.; Grusak, M.A. (2003). "Chickpea leaves as a vegetable green for humans: evaluation of mineral composition". *Journal of the Science of Food and Agriculture* 83: 945–950. doi:10.1002/jsfa.1427.
- Pittaway, JK; Robertson, IK; Ball, MJ (2008). "Chickpeas may influence fatty acid and fiber intake in an ad libitum diet, leading to small improvements in serum lipid profile and glycemic control". *Journal of the American Dietetic Association* 108 (6): 1009–13. doi:10.1016/j.jada.2008.03.009. PMID 18502235.
- Pfaff, T; Kahl, G (2003). "Mapping of gene-specific markers on the genetic map of chickpea ("Cicer atietinum"L)". *Molecular Genetic Genomics* 269: 243–251. doi:10.1007/s00438-003-0828-0.
- Millan, Teresa; Heather, J.Clarke; Kadambot, H.M.Siddique; et.al (2006). "Chickpea molecular breeding:New tools and concepts". *Euphytica* 147: 81–103. doi:10.1007/s10681-006-4261-4.
- Leah A. Zeldes (16 February 2011). "Eat this! Lentils, a prehistoric foodstuff". *Dining Chicago*. Chicago's Restaurant & Entertainment Guide. Retrieved 4 August 2011.
- Mudryj AN, Yu N, Aukema HM (2014). "Nutritional and health benefits of pulses". *Appl Physiol Nutr Metab* 39 (11): 1197–204. doi:10.1139/apnm-2013-0557. PMID 25061763.
- Kawaljit Singh Sandhu, Seung-Taik Lim *Digestibility of legume starches as influenced by their physical and structural properties* Elsevier, 16 March 2007

2.9 SUGGESTED READINGS

- Bonjean, A.P., and W.J. Angus (editors). The World Wheat Book: a history of wheat breeding. Lavoisier Publ., Paris. 1131 pp. (2001). ISBN 2-7430-0402-9.
- Head L., Atchison J., and Gates A. *Ingrained: A Human Bio-geography of Wheat*. Ashgate Publ., Burlington. 246 pp. (2012). ISBN 978-1-4094-3787-1.
- Jasny Naum, *The Wheats of Classical Antiquity, J*. Hopkins Press, Baltimore 1944.
- Heiser Charles B., *Seed to civilisation. The story of food*, (Harvard University Press, 1990).
- Harlan Jack R., *Crops and Man*, American Society of Agronomy, Madison 1975.
- Sauer Jonathan D., *Geography of Crop Plants. A Select Roster*, CRC Press, Boca Raton.
- Watson, Andrew (1983). *Agricultural innovation in the early Islamic world*. Cambridge University Press. ISBN 0-521-06883-5.
- Vespada, Yaowanuch (1998). *The genetic wonder of Thai rice*. Plan Motif Publisher. p. 110.
- Songkran Chitrakon and Boriboon Somrith (2003). *Science and technology with Thai rice, National center for genetic engineering*. The public information department. p. 30.
- *The ecology of life*. Plan Motif Plubisher. 1998. p. 44.
- Vespada, Yaowanuch (1998). *The genetic wonder of Thai rice*. Plan Motif Publisher. p. 45.
- Bonavia, Duccio (2013). *Maize: Origin, Domestication, and Its Role in the Development of Culture*. Cambridge University Press. ISBN 978-1-107-02303-1.

- European Association for Grain Legume Research (AEP). *Pea*. http://www.grainlegumes.com/default.asp?id_biblio=52.
- Hernández Bermejo, J. E. & León, J., (1992). *Neglected crops: 1492 from a different perspective*, Food and Agricultural Organization of the United Nations (FAO) Contents
- Muehlbauer, F. J. and Tullu, A., (1997). *Pisum sativum L.* Purdue University. Pea
- Oelke, E. A., Oplinger E. S., et al. (1991). *Dry Field Pea*. University of Wisconsin.Dry Field Pea
- S S Yadav et al. *Lentil: An Ancient Crop for Modern Times*. (2007). Springer Verlag. ISBN 9781402063121

2.10 TERMINAL QUESTIONS

1. Which plant family the major food crops of the world belong?
2. Where the wheat was first domesticated?
3. Describe different types of wheat. Which wheat is widely cultivated?
4. Which country is the larger exporter of wheat globally?
5. Name the two cultivated species of rice.
6. Where the rice was first originated?
7. Name the three countries which are the world's largest producers of rice.
8. Where are the global rice germplasm accessions are maintained?
9. Which year the draft genomes for the two most common rice cultivars, *indica* and *japonica*, published?
10. Describe different forms of maize. Name various subspecies of maize related to the amount of starch each has.
11. What do you understand by "jumping genes"? Describe its significance in context of maize.
12. Describe the teosinte theory of maize.
13. Which part of the world pearl millet or bajra is most extensively cultivated?
14. Name the international institute located in India that has successfully bred bajra and sorghum varieties grown globally.
15. Where was pigeon pea originated? Which part of the world it is presently cultivated?
16. Name various Indian dishes in which fresh peas are used.
17. Name two most important Asian *Vigna* species used as pulses.
18. Which countries in the world are the top dry bean and green bean producers, respectively?
19. Which institute led the sequencing of the chickpea genome?
20. Which countries lead the lentil production in the world?

UNIT-3 FRUITS, SPICES AND VEGETABLES

Contents

3.1 OBJECTIVES

The major objectives of the present chapter are:

- To study origin, domestication, genetics, cultivation and production of fruits, vegetables, species.
- To learn about the spices, its importance etc.
- To establish link between biology and anthropology and exploiting ways humans use fruits, vegetables species for food and other purposes.

3.2 INTRODUCTION

Fruits and vegetables provide health benefits and are important for the prevention of illnesses. Fruits and vegetables contain a variety of nutrients including vitamins, minerals and antioxidants. Eating the recommended amount of fruits and vegetables each day can reduce the risk of chronic diseases. The healthiest choices are fresh fruits or frozen without added sweeteners. Fruit is naturally low in fat, sodium and calories, and rich in potassium, fibre, vitamin C and folate. Some high-potassium fruits include oranges and bananas. Fibre in fruit helps to protect against heart disease and lower cholesterol. Vitamin C in foods like citrus helps in wound healing and keeps gums and teeth healthy. Vegetables are rich in vitamin A, vitamin C, folate, fibre and potassium. Folate helps the body in formation of red blood cells. It is especially important for pregnant women to consume folate-rich foods such as bell peppers, tomatoes and spinach to prevent neural-tube defects in babies. Vitamin A-rich foods help keep your skin and eyes healthy and protect against infections. A few important fruits, mango, apple, banana, citrus and litchi are described here in the present chapter, beside the vegetables in all four categories, root, stem, leaf and fruits.

Spices are organic plant components that are used to improve the flavour, taste, and colour of foods. The majority of the spices are indigenous to our country, and India has long been regarded as the Land of Spice.

3.3 GENERAL ACCOUNT OF FRUITS

3.3.1-Mango

Mango is one of the juicy and delicious popular fruit grown in the tropics belonging to the genus *Mangifera* in the family *Anacardiaceae*. Mango, more popularly known as the “King of the fruits” is nutritionally rich with unique flavour, fragrance, taste, and health promoting qualities, making it number one among new functional foods, often labelled as “super fruits."

Description

The mango is native to *South Asia* from where it has been distributed worldwide to become one of the most cultivated fruits in the tropics. The centre of diversity of the *Mangifera* genus is in India. While other *Mangifera* species (e.g. horse mango, *Mangifera foetida*) are also grown on a more localized basis. *Mangifera indica*- the "common mango" or "Indian mango"- is the only mango tree commonly cultivated in many tropical and subtropical regions. It is the national fruit of India, Pakistan, and the Philippines, and the national tree of Bangladesh. Mango also has cultural significance.

Mango trees grow up to 35–40 m tall, with a crown radius of 10 m. After flowering its fruits generally grow at the end of a long, string like peduncle, with sometimes more than one fruit to a peduncle. The ripe fruit varies in size and colour. Each fruit measures 5 to 15 cm in length and about 4 to 10 cm in width, and has typical “mango” shape, or sometimes oval or round. Its weight ranges from 150 g to around 750 g. Outer skin (pericarp) is smooth and is green in unripe mangoes but turns in ripe fruits into golden yellow, crimson red, yellow or orange-red depending upon the cultivar type. Fresh mango season lasts from April until August.

Cultivation

Mangoes have been cultivated in South Asia for thousands of years and reached East Asia between the fifth and fourth centuries BC. By the 10th century AD, cultivation had begun in East Africa. The mango is now cultivated in most frost-free tropical and warmer subtropical climates; almost half of the world's mangoes are cultivated in India alone, with the second-largest source being China. Though India is the largest producer of mangoes, it accounts for less than 1% of the international mango trade; India consumes most of its own production. Many of the 1,000+ mango cultivars are easily cultivated using grafted saplings. Dwarf or semi dwarf varieties serve as ornamental plants and can be grown in containers.

Food and other uses

Mangoes are generally sweet, although the taste and texture of the flesh varies across cultivars; some have a soft, pulpy texture similar to an overripe plum, while others are firmer, like a cantaloupe or avocado, and some may have a fibrous texture. The skin of unripe, pickled, or cooked mango can be consumed, but has the potential to cause contact dermatitis of the lips, gingiva, or tongue in susceptible people.

Mangoes are widely used in cuisine. Sour, unripe mangoes are used in chutneys, pickles, side dishes, or may be eaten raw with salt, chilli, or soy sauce. A summer drink called *aam panna* comes from mangoes. Mango pulp made into jelly or cooked with red gram *dhal* and green chillies may be served with cooked rice. Mango lassi is popular throughout South Asia, prepared by mixing ripe mangoes or mango pulp with buttermilk and sugar. Ripe mangoes are also used to make curries. *Aamras* is a popular thick juice made of mangoes with sugar or milk, and is consumed with *chapatis* or *pooris*. The pulp from ripe mangoes is also used to make jam.

Mangoes are used as preserve food such as *moramba*, *amchur* (dried and powdered unripe mango), and pickles, including a spicy mustard-oil pickle and alcohol. Mango is used to make juices, smoothies, ice cream, fruit bars, pies, and sweet chili sauce or a sweet and spicy chilli paste. In other parts of Southeast Asia, mangoes are pickled with fish sauce and rice vinegar. Mango with condensed milk may be used as a topping for shaved ice.

Nutritional value

The energy value per 100 g serving of the common mango is 60 kcal, and that of the apple mango is slightly higher (79 kcal per 100g). Fresh mango contains a variety of nutrients, but only vitamin C and folate are in significant amounts of the Daily Value as 44% and 11%, respectively. Numerous phytochemicals are present in mango peel and pulp. Mango peel pigments include carotenoids, such as the provitamin A compound, beta-carotene, lutein and alpha-carotene, and polyphenols. Mango contains a unique xanthonoid called mangiferin. Up to 25 different carotenoids have been isolated from mango pulp, the densest of which was beta-carotene, which accounts for the yellow-orange pigmentation of most mango cultivars.

The flavour of mango fruits is constituted by several volatile organic chemicals mainly belonging to terpene, furanone, lactone, and ester classes. Different varieties or cultivars of mangoes can have flavour made up of different volatile chemicals or same volatile chemicals in different quantities. In India, 'Alphonso' is one of the most popular cultivars. In 'Alphonso' mango, the lactones and furanones are synthesized during ripening; whereas terpenes and the other flavourants are present in both the developing (immature) and ripening fruits. In contrast to the huge amount of information available on the chemical composition of mango flavour, the biosynthesis of these chemicals has not been studied in depth; only a handful of genes encoding the enzymes of flavour biosynthetic pathways have been characterized to date.

3.3.2-Apple

The apple tree (*Malus domestica*), is a deciduous tree in the family Rosaceae. Apple trees prosper in areas with warm summers and dry climates. They cannot be grown north of the Arctic Circle. While the fruit-bearing trees are mainly grown in the northern hemisphere, some are now being grown in Australia and New Zealand as well.

Origin and domestication

The tree originated in Central Asia, where its wild ancestor, *Malus sieversii*, is still found today. Apples have been grown for thousands of years in Asia and Europe, and were brought to North America by European colonists. Apples have religious and mythological significance in many cultures, including Norse, Greek and European Christian traditions.

The original wild ancestor of *Malus domestica* was *Malus sieversii*, found growing wild in the mountains of Central Asia in southern Kazakhstan, Kyrgyzstan, Tajikistan, and Xinjiang, China. Significant exchange with *Malus sylvestris*, the crabapple, resulted in current populations of apples being more related to crabapples than to the more morphologically similar progenitor *Malus sieversii*. In strains without recent admixture the contribution of the latter predominates.

Production

About 80 million tons of apples were grown worldwide in 2013, and China produced almost half of this total. The United States is the second-leading producer, with more than 6% of world production. Turkey is third, followed by Italy, India and Poland. Apples are often eaten raw, but can also be found in many prepared foods (especially desserts) and drinks. Many beneficial health effects are thought to result from eating apples; however, two types of allergies are attributed to various proteins found in the fruit.

Cultivars

There are more than 7,500 known cultivars of apples. Cultivars vary in their yield and the ultimate size of the tree, even when grown on the same rootstock. Different cultivars are available for temperate and subtropical climates. Most of these cultivars are bred for eating fresh (dessert apples), though some are cultivated specifically for cooking (cooking apples) or producing cider. Red Delicious trees are the most popular variety in apple growing regions worldwide. Most North Americans and Europeans favour sweet, subacid apples, but tart apples have a strong minority following. Extremely sweet apples with barely any acid flavour are popular in Asia and especially Indian Subcontinent.

Genome

In 2010, an Italian-led consortium announced they had decoded the complete genome of the apple in collaboration with horticultural genomicists at Washington State University, using the Golden delicious variety. It had about 57,000 genes, the highest number of any plant genome studied to date and more genes than the human genome (about 30,000). This new understanding of the apple genome will help scientists in identifying genes and gene variants that contribute to resistance to disease and drought, and other desirable characteristics. Decoding the genome also provided proof that *Malus sieversii* was the wild ancestor of the domestic apple-an issue that had been long-debated in the scientific community.

3.3.3-Banannа

The banana is an edible fruit, botanically a berry, produced by several kinds of large herbaceous flowering plants in the genus *Musa*. Banana is, in fact, not a tree but a high herb that grows up to 15 metres. It is believed that there are almost 1000 varieties of bananas in the world, subdivided in 50 groups. The most commonly known banana is the Cavendish variety, which is the one produced for export markets.

Origin and domestication

It is believed that the earliest written reference to banana is in Sanskrit and dates back to around 500 BC. Bananas are suspected to be the first fruit in the earth by some horticulturists. Their origin is placed in Southeast Asia, in the jungles of Malaysia, Indonesia or Philippines, where many varieties of wild bananas still grow today. Africans are credited to have given the present name, since the word banana would be derived from the Arab for 'finger'. They started to be traded internationally by the end of fourteenth century. The development of railroads and technological advances in refrigerated maritime transport subsequently enabled bananas to become the most important world traded fruit.

Taxonomy

The classification of cultivated bananas has long been a problematic issue for taxonomists. Linnaeus originally placed bananas into two species based only on their uses as food: *M. sapientum* for dessert bananas and *M. paradisiaca* for plantains (less sweet). Subsequently further species names were added. However, this approach proved inadequate to address the sheer number of cultivars existing in the primary centre of diversity of the genus, Southeast Asia. Many of these cultivars were given names which proved to be synonyms.

The currently accepted scientific names for most groups of cultivated bananas are *M. acuminata* Colla and *M. balbisiana* Colla for the ancestral species, and *M. paradisiaca* L. for the hybrid *M. acuminata* × *M. balbisiana*. Almost all modern edible parthenocarpic (seedless) bananas come from two wild species - *M. acuminata* and *M. balbisiana*. The scientific names of most cultivated bananas are *M. acuminata*, *M. balbisiana*, and *M. paradisiaca* for the hybrid *M. acuminata* × *M. balbisiana*, depending on their genomic constitution. The old scientific name *M. sapientum* is no longer used.

Generally, modern classifications of banana cultivars follow Simmonds and Shepherd's system. Cultivars are placed in groups based on the number of chromosomes they have and which species they are derived from. Thus the Latundan banana is placed in the AAB Group, showing that it is a triploid derived from both *M. acuminata* (A) and *M. balbisiana* (B). In 2012, a team of scientists announced they had achieved a draft sequence of the genome of *M. acuminata*.

Cultivation, production and export

Bananas are grown in more than 150 countries, producing 105 million tonnes of fruit per year. The bananas grown for local consumption are generally grown in traditional, extensive systems. Dessert bananas account for 43 million tonnes per year and are of huge economic importance for many countries in the South. Cooking bananas (plantains and others) account for 45 million tonnes. Locally consumed bananas, which are a staple food in many tropical countries, play a major role in terms of food security.

The banana plant is the largest herbaceous flowering plant. All the above-ground parts of a banana plant grow from a structure usually called a "corm". Plants are normally tall and fairly sturdy, the trunk is actually a "false stem" or pseudostem. Cultivated bananas are parthenocarpic, i.e. the flesh of the fruit swells and ripens without its seeds being fertilized and developing. Lacking viable seeds, propagation typically involves farmers removing and transplanting part of the underground stem. Usually this is done by carefully removing a sucker with some roots intact.

Cavendish bananas are the main commercial banana cultivars sold in the world market, belonging to the triploid AAA group of *M. acuminata*. Ease of transport and shelf life rather than superior taste make the Dwarf Cavendish the main export banana. Bananas must be transported over long distances from the tropics to world markets. The 2012 statistics show that India led the world in banana production, producing around 18% of the worldwide crop of 139 million metric tonnes. Philippines were the next largest producer with around 7% of the worldwide crop. Its national data does distinguish between bananas and plantains, and shows that the latter made up over 95% of production. Ten countries produced around two thirds of the total world production.

Nutritional value and uses

Bananas and plantains constitute a major staple food crop for millions of people in developing countries. Bananas are an excellent source of vitamin B_6 and contain moderate amounts of vitamin C, manganese and dietary fibre. Ripe bananas were found to contain serotonin, dopamine and norepinephrine.

The banana plant has long been a source of fibre for high quality textiles. In Japan, banana cultivation for clothing and household use dates back to at least the 13th century. Banana fibre is also used in the production of banana paper. Banana paper is made from two different parts: the bark of the banana plant mainly used for artistic purposes, or from the fibres of the stem and non-usable fruits. The paper is either hand-made or by industrial process.

3.3.4-Citrus

Citrus is a common term and genus (*Citrus*) of flowering plants in the family Rutaceae.

Origin and domestication

The most recent research indicates an origin of *Citrus* in Australia, New Caledonia and New Guinea. Some researchers believe that the origin is in the part of Southeast Asia bordered by Northeast India, Burma (Myanmar) and the Yunnan province of China, and it is in this region that some commercial species such as oranges, mandarins, and lemons originated. Citrus fruit has been cultivated in an ever-widening area since ancient times; the best-known examples are the oranges, lemons, grapefruit, and limes.

Taxonomy

The taxonomy and systematics of the genus are complex and the precise number of natural species is unclear, as many of the named species are hybrids clonally propagated through seeds (by apomixis), and there is genetic evidence that even some wild, true-breeding species are of hybrid origin. Most cultivated *Citrus* seem to be natural or artificial hybrids of four core ancestral species-the citron (*C. medica* L.), pummelo (*C. maxima* or *C.grandis)*, mandarine (*C. reticulata*), and papeda (*Citrus* subg *Papeda*). Natural and cultivated citrus hybrids include commercially important fruit such as oranges, grapefruit, lemons, limes, and some tangerines.

Apart from these four core citrus species, there are Australian limes and the recently-discovered Mangshanyegan, Kumquats and *Clymenia sp.* are now generally considered to belong within the Citrus genus. Trifoliate orange, which is often used as commercial rootstock, is an out-group and may or may not be categorized as a citrus.

Citrus trees hybridise very readily - depending on the pollen source. Thus all commercial citrus cultivation uses trees produced by grafting the desired fruiting cultivars onto rootstocks selected for disease resistance and hardiness.

Description

The colour of citrus fruits only develops in climates with a (diurnal) cool winter. In tropical regions with no winter at all, citrus fruits remain green until maturity, hence the tropical "green oranges". The Persian lime in particular is extremely sensitive to cool conditions, thus it is not usually exposed to cool enough conditions to develop a mature colour. If they are left in a cool place over winter, the fruits will change colour to yellow.

The terms "ripe" and "mature" are usually used synonymously, but they mean different things. A mature fruit is one that has completed its growth phase. Ripening is the changes that occur within the fruit after it is mature to the beginning of decay. These changes usually involve starches converting to sugars, a decrease in acids and a softening and change in the fruit's colour.

Citrus trees are not generally frost hardy. Mandarin oranges (*C. reticulata*) tend to be the hardiest of the common *Citrus* species and can withstand short periods down to as cold as -10°C, but realistically temperatures not falling below -2°C are required for successful cultivation. Tangerines can be grown outside even in regions with more marked sub-freezing temperatures in winter, although this may affect fruit quality. The related trifoliate orange (*C. trifoliata*) can survive below -20 °C; its fruit are astringent and inedible unless cooked but a few better-tasting cultivars and hybrids have been developed.

Cultivation

Major commercial citrus growing areas include southern China, the Mediterranean Basin (including southern Spain), South Africa, Australia, the southern most United States, Mexico and parts of South America. In the United States, Florida, California, Arizona, and Texas are major producers, while smaller plantings are present in other Sun Belt states and in Hawaii. According to UN 2007 data, Brazil, China, the United States, Mexico, India, and Spain are the world's largest citrus-producing countries.

Uses

Many citrus fruits, such as oranges, tangerines, grapefruits, and clementines, are generally eaten fresh. They are typically peeled and can be easily split into segments. Grapefruit is more commonly halved and eaten out of the skin with a spoon. Orange and grapefruit juices are also very popular breakfast beverages. More acidic citrus, such as lemons and limes, are generally not eaten on their own. Lemons and limes are also used as garnishes or in cooked dishes.

A variety of flavours can be derived from different parts and treatments of citrus fruits. Citrus juices, rinds, or slices are used in a variety of mixed drinks. The colourful outer skin of some citrus fruits, known as zest, is used as flavouring in cooking; the white inner portion of the peel, the pith, is usually avoided due to its bitterness.

Oranges were historically used for their high content of vitamin C, which prevents scurvy. Pectin is a structural heteropolysaccharide contained in the primary cell walls of plants. Limes and lemons as well as oranges and grapefruits are among the highest in this level. After consumption, the peel is sometimes used as a facial cleanser. Before the development of fermentation-based processes, lemons were the primary commercial source of citric acid.

3.3.5-Litchi

The litchi (*Litchi chinensis*) is the sole member of the genus *Litchi* in the family, Sapindaceae. It is a tropical and subtropical fruit tree native to the Guangdong and Fujian provinces of China, and now cultivated in many parts of the world. The fresh fruit has a "delicate, whitish pulp" with a floral smell and a fragrant, sweet flavour. Since this perfume-like flavour is lost in the process of canning, the fruit is usually eaten fresh.

Description

L. chinensis is an evergreen tree that is frequently less than 19 m tall. The litchi bears fleshy fruits that are up to 5 cm long and 4 cm wide. Fruits mature in 80–112 days, depending on climate, location, and cultivar. Fruits vary in shape from round to ovoid to heart-shaped. The fleshy, edible portion of the fruit is an aril, surrounding one dark brown inedible seed that is 1 to 3.3 cm long and 0.6 to 1.2 cm wide. Some cultivars produce a high percentage of fruits with shrivelled aborted seeds known as 'chicken tongues'. These fruit typically have a higher price, due to having more edible flesh.

Cultivation and production

China is the main producer of litchi, followed by India, with production occurring among other countries in Southeast Asia, the Indian subcontinent and South Africa.

Cultivation of litchi began in the region of southern China, Malaysia, and northern Vietnam. Wild trees still grow in rainforests in Guangdong province and on Hainan Island. Unofficial records in China refer to litchi as far back as 2000 BC. There are numerous litchi cultivars, with considerable confusion regarding their naming and identification. The same cultivar grown in different climates can produce very different fruit. Cultivars can also have different synonyms in various parts of the world. Different cultivars of litchi are popular in the varying growing regions and countries. India grows more than a dozen named cultivars, including Shahi (Highest Pulp %), Dehradun, Early Large Red, Kalkattia, Rose Scented.

Nutritional value

Fresh whole litchi contains a total 72 mg of vitamin C per 100 g of fruit, an amount representing 86% of the Daily Value (DV). On average, consuming nine peeled litchi fruits would meet an adult's daily vitamin C requirement but otherwise would supply little nutrient content. Litchi are low in saturated fat and sodium. Litchi has moderate amounts of polyphenols, shown in one French study to be higher than several other fruits analyzed, such as grapes and apples.

3.4 SPICES

Spices are organic plant components used to enhance the flavour, fragrance, and colour of culinary items. They can be derived from the following plant parts: roots, rhizomes, stems, leaves, bark, flowers, fruits, and seeds. They are also utilised in food, alcohol, cosmetic, and perfume industries. Most of the spices are native of our country and India has a long history of being known as the **Land of Spice.** There is no diversity of spice crops like India in any other country of the world. Indian spices are famous for their excellent aroma, taste and sharpness.

Condiments are also spices, the byproducts of which are exclusively used to enhance flavour in cuisine. Essential oils are responsible for the flavour and taste in both spices and condiments. Little nutritional value may be found in them. They are mostly used for flavouring and flavouring food and can be found in whole, ground, paste, or liquid form. Most spices, especially the dry kinds, extend food's shelf life. Some are added to enhance texture, while others are added to provide a flavorful colour or odour.

Spices have a long history and were formerly a major source of wealth and power. The earliest instances of herbs and spices being used by humans as flavourings are unknown. There is evidence of the use of garlic and onions 4,500 years ago. Prior to the invention of refrigeration, humans utilised spices to preserve food. Early spice trade routes were developed by Arab traders. The commercial routes to the Mediterranean were widened by the Greeks. With the spice trade, the Roman Empire possessed considerable power and control. In order to maintain their dominance, seafaring countries like Portugal, Spain, Holland, and Britain engaged in numerous conflicts and entered the lucrative spice trade. The spice monopolies were broken up as plantations for pepper, nutmeg, cinnamon, and other vital spices were built on tropical islands.

3.4.1 CLASSIFICATION OF SPICES

Spices can be divided into many categories based on-

1-Plant parts utilised, including leaves, flowers, barks, rhizomes, fruits, and seeds.

2-Botanical relationship: the family to which it belongs.

3-Perennial, biennial, and annual spice plant longevity

4- The morphology of the aerial parts of spice plants, including climbers, shrubs, trees, and herbs with aerial stems or pseudostems etc.

Each classification has some gaps or overlaps, therefore none of them are complete. Therefore, at this time, a mixed combination of the aforementioned classification is typically followed as follows:

a) Major spices: Cardamom, Black Pepper, Ginger and Turmeric

b) Seed spices (Minor spices): Coriander, Fennel, Cumin, Fenugreek, Dill, Aniseed, Caraway, Celery and Bishop Weed.

c) Tree spices: Clove, Nutmeg, Cinnamon, All spice, Cassia, Tamarind, Bay leaf, Curry leaf etc.

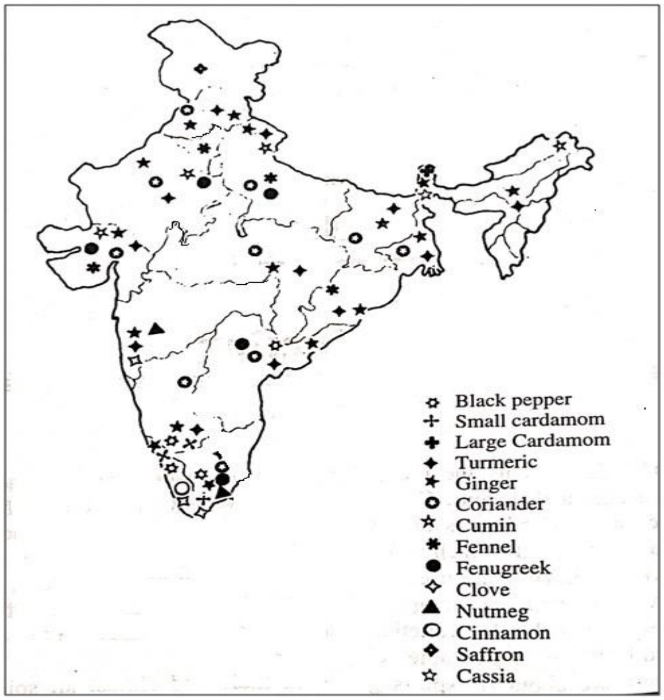
d) Herbal spices: Rosemary, Thyme, Horse radish, Parsley etc.

e) Other spices: Vanilla, Saffron, Asafoetida, Garlic etc.

3.4.2 AREA AND PRODUCTION

There are about 63 spices grown in India and almost all spices can be grown in India because of the varied climate-tropical, subtropical and temperate prevailing in India (Fig. 1. and Table 1.). Some of the most significant spices are pepper, cardamom, chilli, ginger, turmeric, coriander, cumin, fennel, fenugreek, celery, saffron, tamarind, and garlic. Aniseed, bishop's weed, dill seed, poppy seeds, curry leaves, cinnamon, and cocoa are some of the spices that are produced in small quantities and exported. However, some spices are grown in the nation to ensure adequate production. These spices include thyme, basil, marjoram, cloves, nutmeg, and allspice. There is enormous potential for production and export of vanilla and paprika, which have not yet begun commercial cultivation.

Kerala is the leading state in the production of pepper in the country, which contributes to 95% area and 97% production. In 2017–18, 1,34000 hectors of pepper were grown in India. Which has been higher than in recent years, mostly as a result of the pepper’s current appealing prices on both the domestic and foreign markets? However, it is important to note that despite the country's extremely favourable environment, enhanced varieties, and advanced methods of cultivation, the productivity of pepper in the country is much lower than in other chilli producing countries.



The Indian Institute of Spices Research (IISR), Calicut a constituent body of Indian Council of Agricultural Research (ICAR) is a major Institute devoted to research on spices. In 1976, it started as a Regional Station of the Central Plantation Crops Research Institute (CPCRI), Kasaragod engaged in research on spices.

A National Research Centre for Spices was established in 1986 with its headquarters at Calicut, Kerala by merging the erstwhile Regional Station of CPCRI at Calicut and Cardamom Research Centre at Appangala, Karnataka. Realising the importance of Spices Research in India this Research Centre was upgraded to Indian Institute of Spices Research on 1st July, 1995.

Fig. 3.1 Locations where major spices are grown in India

Table-1 List of commonly used spices of India wih their botanical name and part used as spices

S.No.	Botanical Name	Common name	Family	Parts Used
1.	*Allium sativum* L.	Garlic	Alliaceae	Bulb
2.	*Trachyspermum ammi* L.	Ajowan	Apiaceae	Seed
3.	*Coriandrum sativum* L.	Coriander	Apiaceae	Leaf & seed
4.	*Cuminum cyminum* L	Cumin	Apiaceae	Seed
5.	*Carum carvi* L.	Caraway	Apiaceae	Seed
6.	*Foeniculum vulgare* Mill.	Fennel	Apiaceae	Seed
7.	*Ferula asafoetida* L	Asafoetida	Apiaceae	Oleogum resin
8.	*Petroselinum crispum* Mill.	Parsley	Apiaceae	Leaf
9.	*Apium graveolens* L.	Celery	Apiaceae	Leaf & Stem
10.	*Pimpinella anisum* L.	Aniseed	Apiaceae	Seed
11.	*Anethum graveolens* L.	Dill	Apiaceae	Leaves and seed
12.	*Levisticum officinale* Koth.	Lovage	Apiaceae	Leaf&Stem
13.	*Artemisia dracunculus* L.	Tarragon	Asteraceae	Leaf
14.	*Acorus calamus* L.	Sweet flag	Araceae	Rhizome
15.	*Brassica juncea* L.Czern	Mustard	Brassicaceae	Seed
16.	*Armoracia rusticana* Gaertn	Horse Radish	Brassicaceae	Root
17.	*Capparis spinosa* L.	Caper	Capparidaceae	Flower buds
18.	*Garcinia cambogia* (Gaertn).Desr	Camboge	Clusiaceae	Rind
19.	*Garcinia indica* Choisy	Kokam	Clusiaceae	Outer rind of fruit
20.	*Juniperus communis* L.	Juniper berry	Cupressaceae	Berry
21.	*Tamarindus indica* L.	Tamarind	Caesalpiniaceae	Fruit

22.	*Trigonella foenum-graecum* L.	Fenugreek	Fabaceae	Seed
23.	*Capsicum frutescens* L	Chilli, Hot Pepper	Solanaceae	Fruit
24.	*Capsicum annuum* L.	Capsicum, Chilli,	Solanaceae	Fruit
25.	*Cinnamomum zeylanicum* Breyn	Cinnamon	Lauraceae	Bark
26.	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & Eberm.	Tejpat	Lauraceae	Leaves
27.	*Cinnamomum cassia* Blume	Cassia	Lauraceae	Bark
28.	*Laurus nobilis* L.	Bay Leaf	Lauraceae	Leaf
29.	*Murraya koenigii* (L) Sprengel	Curry leaf	Rutaceae	Leaf
30.	*Crocus sativus* L.	Saffron	Iridaceae	Stigma
31.	*Illicium verum* Hook.	Star Anise	Illiciaceae	Fruit
32.	*Marjorana hortensis* Moench.	Marjoram	Lamiaceae	Leaf
33.	*Ocimum basilicum* L.	Basil	Lamiaceae	Leaf
34.	*Rosmarinus officinalis* L.	Rosemary	Lamiaceae	Leaf
35.	*Salvia officinalis* L.	Sage	Lamiaceae	Leaf
36.	*Satureja hortensis* L.	Savory	Lamiaceae	Leaf
37.	*Thymus vulgaris* L.	Thyme	Lamiaceae	Leaf
38.	*Origanum vulgare* L.	Oregano	Lamiaceae	Leaf
39.	*Mentha piperita* L.	Mint	Lamiaceae	Leaf
40.	*Hyssopus officinalis* L.	Hyssop	Lamiaceae	Leaf
41.	*Syzygium aromaticum* (L) Merr. & Perry	Clove	Myrtaceae	Flower bud
42.	*Pimenta dioica* (L) Merr.	Allspice	Myrtaceae	Fruit & Leaf
43.	*Myristica fragrans* Houtt.	Nutmeg	Myristicaceae	Seed
44.	*Vanilla planifolia* Andr.	Vanilla	Orchidaceae	Pod
45.	*Piper longum* L.	Pepper Long	Piperaceae	Fruit
46.	*Piper nigrum* L	Pepper	Piperaceae	Fruit
47.	*Papaver somniferum* L.	Poppy seed	Papaveraceae	Seed
48.	*Punica granatum* L.	Pomegranate	Punicaceae	Seed
49.	*Amomum subulatum* Roxb.	Cardamom large	Zingiberaceae	Fruit, Seed
50.	*Elettaria cardamomum* Maton	Cardamom small	Zingiberaceae	Fruit, Seed
51.	*Zingiber officinale* Rosc.	Ginger	Zingiberaceae	Rhizome
52.	*Curcuma longa* L.	Turmeric	Zingiberaceae	Rhizome
53.	*Alpinia galanga* Willd.	Greater Galanga	Zingiberaceae	Rhizome

3.4.3 IMPORTANCE OF SPICES IN INDIA

Since ancient times, spices have been valued as being crucial to food's flavour and have a significant place in agricultural commodities. Some are employed in the pharmaceutical, cosmetic, and other industries, while others serve as colour pigments, preservatives, antioxidants, antiseptics, antibiotics, and other functions. Additionally, they contribute significantly to the Indian economy as a whole.

1. India has been a traditional and largest producer, consumer and to exporter of spices.

2. India produces spices on 3.08 million ha with an annual production of about 5.4 million tonnes valued at about Rs. 4500 crores, contributing nearly 20% of world's production, 30% of the trade in terms of quantity but only 10% in terms of value.
3. No other country in the world grows as many kinds of spices as India.
4. Nearly 90-95% of the total production is consumed locally and the rest exported.
5. India is the biggest exporter of spices and annually exporting about 1,404,357 tonnes of spices and spice products valued around Rs. 3,176,138.22 lakh.
6. The export of spices and spice products is growing up every year.
7. They are indispensable part of our culinary preparations especially used for flavouring and seasoning of food.
8. In the daily intake of food and culinary preparations, the Indian food habits amalgamate divergent spices and exploit and utilize phytochemicals to add aroma and health in our daily life.
9. Most of the spices have potential medicinal values. Besides, the spices and spice products are also indirectly used as flavouring or colouring agents or as preservatives in many pharmaceutical preparations.
10. Spices have been used in cosmetic and perfumery industries. Spice oils are used in the manufacture of soaps, tooth pastes, talcum powder, after shave lotions, vanishing creams, mouth fresheners and room fresheners etc.

3.4.4 CONSTRAINTS IN INDIAN SPICE INDUSTRY

There are various constraints which are affect the quality and quantity of spices in India. Some of the factors are given below:

1. Low farm productivity and high production costs.
2. The absence of high yielding cultivars from farmer fields.
3. The lack of high yielding planting materials of good quality.
4. Crop loss as a result of severe disease and pest incidence
5. Poor post-harvesting methods
6. An insufficient extension network.
7. Price turbulence.
8. Mycotoxins (Aflatoxin) contamination negatively impacts the ability of high-value commodities crops to export.
9. Strict food regulations by the nations that import food - Indiscriminate use of plant protection chemicals leads in pesticide residues over the MRL, leading to the rejection of numerous consignments of spices.
10. Harsh competition from other producing nations - The majority of exporting nations don't have a domestic market for the spices they produce, which forces them to sell their goods even below cost (cardamom from Guatemala, pepper from Vietnam, cloves & nutmeg from Indonesia).

3.5 GENERAL ACCOUNT OF VEGETABLES

3.5.1-Root Vegetables

Root vegetables are underground plant parts used as vegetables. They are called root vegetables, but include both true roots such as tuberous roots and taproots, as well as non-roots such as tubers, rhizomes, corms, bulbs, and hypocotyls.

Root vegetables are generally storage organs, enlarged to store energy in the form of carbohydrates. They differ in the concentration and the balance between sugars, starches, and other types of carbohydrate. Of particular economic importance are those with a high carbohydrate concentration in the form of starch. Starchy root vegetables are important staple foods, particularly in tropical regions, overshadowing cereals throughout much of West Africa, Central Africa and Oceania, where they are used directly or mashed to make fufu or poi. Yams, beets, parsnips, turnips, rutabagas, carrots, yuca, kohlrabi, onions, garlic, celery root (or celeriac), horseradish, daikon, turmeric, jicama, Jerusalem artichokes, radishes, and ginger are all considered roots.

Because root vegetables grow underground, they absorb a great amount of nutrients from the soil. They are packed with a high concentration of antioxidants, Vitamins C, B, A, and iron, helping to cleanse your system. They are also filled with slow-burning carbohydrates and fibre, which make you feel full, and help regulate your blood sugar and digestive system. This factor, plus the high-octane nutrients and low calories, make roots excellent for people who are trying to lose weight, or simply stay healthy.

Adding up all of the nutrient qualities, root vegetables are disease-fighting, immunity and energy-boosting, and are also extremely versatile in cooking.

The following list classifies root vegetables according to anatomy.

True root: Storage roots are very common all over the world. There are more than 50 types of storage roots (categorised in bulb, rhizome, tubers).

1-**Taproot** (some types may incorporate substantial hypocotyl tissue)

- *Arracacia xanthorrhiza* (arracacha)
- *Beta vulgaris* (beet and mangelwurzel)
- *Brassica* spp. (rutabaga and turnip)
- *Bunium persicum* (black cumin)
- Burdock (*Arctium, family Asteraceae*)
- Carrot (*Daucus carota subsp. sativus*)
- Celeriac - (*Apium graveolens rapaceum*)
- Daikon - the large East Asian white radish (*Raphanus sativus var. longipinnatus*)

- Dandelion - (*Taraxacum*) spp.
- *Lepidium meyenii* (maca)
- *Microseris scapigera* (yam daisy)
- *Pachyrhizus* spp. (jicama and ahipa)
- Parsnip (*Pastinaca sativa*)
- *Petroselinum* spp. (parsley root)
- Radish - (*Raphanus sativus*)
- *Scorzonera hispanica* (black salsify)
- *Sium sisarum* (skirret)
- *Tragopogon* spp. (salsify)
- *Vigna lanceolata* (bush potato)

2-**Tuberous root**

- *Amorphophallus galbra* (Yellow lily yam)
- *Conopodium majus* (pignut or earthnut)
- *Dioscorea opposita* (nagaimo, Chinese yam, Korean yam)
- *Hornstedtia scottiana* (Native ginger)
- *Ipomoea batatas* (sweet potato)
- *Ipomoea costata* (desert yam)
- *Manihot esculenta* (cassava or yuca or manioc)
- *Mirabilis extensa* (mauka or chago)
- *Psoralea esculenta* (breadroot, tipsin, or prairie turnip)
- *Smallanthus sonchifolius* (yacón)

Modified plant stem

1-**Corm**

- *Amorphophallus konjac* (konjac)
- *Colocasia esculenta* (taro)
- *Eleocharis dulcis* (Chinese water chestnut)
- *Ensete* spp. (enset)
- *Nelumbo nucifera*
- *Nymphaea* spp. (waterlily)
- *Pteridium esculentum*
- *Sagittaria* spp. (arrowhead or wapatoo)
- *Typha spp.*
- *Xanthosoma* spp. (malanga, cocoyam, tannia, and other names)

2- **Rhizome**

- *Curcuma longa* (turmeric)

- *Panax ginseng* (ginseng)
- *Arthropodium* spp. (rengarenga, vanilla lily, and others)
- *Canna* spp. (canna)
- *Cordyline fruticosa* (ti)
- *Maranta arundinacea* (arrowroot)
- *Nelumbo nucifera* (lotus root)
- *Typha* spp. (cattail or bulrush)
- *Zingiber officinale* (ginger, galangal)

3-**Tuber**

- *Apios americana* (hog potato or groundnut)
- *Cyperus esculentus* (tigernut or chufa)
- *Dioscorea* spp. (yams, ube)
- *Helianthus tuberosus* (Jerusalem artichoke or sunchoke)
- *Hemerocallis* spp. (daylily)
- *Lathyrus tuberosus* (earthnut pea)
- *Oxalis tuberosa* (oca or New Zealand yam)
- *Plectranthus edulis* and *P. esculentus* (kembili, dazo, and others)
- *Solanum tuberosum* (potato)
- *Stachys affinis* (Chinese artichoke or crosne)
- *Tropaeolum tuberosum* (mashua or añu)
- *Ullucus tuberosus* (ulluco)

4-Bulb

- *Allium* spp. (garlic, onion, shallot, etc.)

3.5.2-Stem Vegetables

Stem vegetables are plant stems used as vegetables. Although many leaf vegetables, root vegetables, and inflorescence vegetables in fact contain substantial amounts of stem tissue, the term is used here only for those vegetables composed primarily of above-ground stems.

Important crops found in category of stem vegetables include: 1) Asparagus, 2) Bamboo, 3) Blanched celery, 4) Celery, 5) Celtuce, 6) Florence fennel, 7) Good King Henr, 8) Kohlrabi, 9) Lotus, 10) Moso bamboo, 11) Oldhams bamboo, 12) Rhubarb, 13) Sago palm, 14) Sea kale, etc. A few examples of stem vegetables with edible above ground stems are as follows:

Crop name	**Scientific name**	**Family**	**Collective name for members of the family, other information**
Asparagus	*Asparagus officinalis*	Asparagaceae	Asparagus family (formerly under Liliaceae); the edible part is the young shoot commonly called "spear," best

			consumed when the tip is still tightly closed.
Bamboos	Various species	Poaceae/ Gramineae	Grass family; the edible part is the young, newly emerged shoot.
Kohlrabi	*Brassica oleracea var. gongylodes*	Brassicaceae/ Cruciferae	Mustard family, also called Cole Crops and Crucifers; the main consumable plant part is the basal stem which forms a spherical structure.
Potato vine, kangkong	*Ipomoea aquatica*	Convolvulaceae	Morning Glory/Bindweed family; both stems and leaves are eaten cooked or blanched.

3.5.3-Leafy Vegetables

Humans have used leaves as food since time immemorial. Different types of leaves, depending from the place and the season, were part of the human diet since prehistoric times. With the passing of the centuries many of those traditional leaf vegetables have been replaced by leaves that are more tender, have a more neutral taste or that are considered more refined. The leaves that were part of ancient traditional diets are still to be found in the wild, sometimes at the edge of cultivated fields, or near abandoned homesteads.

Below is the list of vegetables which are grown primarily for the consumption of their leafy parts, either raw or cooked. Many plants with leaves that are consumed in small quantities as a spice like oregano, or for medicinal purposes like lime, or used in infusions like tea, are not included in this list.

Species	Common name	Observations
Amaranthus cruentus	Purple amaranth	Thai: *phak khom daeng*. Vietnamese: *rau dên*. Amaranthus species are edible and have a pleasant taste, but contain a certain proportion of oxalic acid and should preferably be eaten after boiling and disposing of the water.
Amaranthus tricolor	Amaranth	Amarant hybrids, often from hydroponic cultivation, are popular in China and other Asian countries. They are usually eaten blanched.
Apium graveolens	Celery	Generally the stalk is preferred, but the leaves are a staple in many soups. Some people have celery allergy which can cause potentially fatal anaphylactic shock.
Brassica napus	Rutabaga	*Sag*, popular in Indian and Nepalese cuisine, usually stir-fried with salt, garlic and spices.

Brassica nigra	Black Mustard	Black mustard is commonly found in neglected gardens, on roadsides, in abandoned fields, and in areas where waste is disposed of. The plant is native to Asia and Europe, but now grows over much of southern Canada and almost all of the United States. This is the chief mustard used in condiments and as such is normally associated with hot-dogs. To make the mustard condiment, the seeds must be ground fine and then mixed with flour and a small portion of water and vinegar. The plant can be cultivated for its young leaves which are used in a salad or as a pot herb.
Brassica oleracea var. Acephala	Kale	Kale is a type of cabbage that has flat or curly leaves and stem colors ranging from dark green to burgundy. Kale contains many nutrients including calcium, iron, and vitamins A, C, and K. Young leaves can be harvested to use fresh in salads or allowed to mature and used as a cooked green. Kale can be found throughout the summer months, but is especially good after a frost.
Brassica rapa	Turnip	Leaves popular in the southern United States, Galicia, Spain (*Grelos*).
Celosia argentea var. Argentea	Wild Coxcomb	Known as "Lagos spinach", it is one of the main boiled greens in West Africa.
Chenopodium album	Lamb's Quarters	Popular type of *Palak* in Northern India. Also used to stuff paratha.
Chenopodium ambrosioides	American Wormseed	*Chenopodium* species are edible, but many species are mediocre as a leaf vegetable.
Chenopodium bonus-henricus	Good King Henry	One of the finest *Chenopodium* species.
Chenopodium quinoa subsp. quinoa	Quinoa	It has its origin in the Andean region.
Coriandrum sativum	Cilantro, Coriander	Used mainly for garnishing or in small quantities.
Crambe maritima	Sea kale	It was popular as a blanched vegetable in the early 19th Century, but its use declined
Crotalaria longirostrata	Chipilín	A common leafy vegetable in the local cuisines of southern Mexico.
Cyclanthera pedata	Caigua	Traditional green in Central America and South America.

Diplazium esculentum	Vegetable fern	Probably the most commonly consumed fern.
Gynura crepioides	Okinawan Spinach	Grown commercially as a vegetable in China
Hibiscus sabdariffa	Roselle	Telugu: *Gongura*. Roselle leaves are edible and have a pleasant taste. This plant is having good medicinal values. In some areas it is used as substitute of Jute.
Ipomoea aquatica Forssk.	Water Spinach	Popular leafy green in Southeast Asia.
Lablab purpureus	Lablab	The leaves are used as greens, but have to be cooked like spinach and the water has to be discarded.
Lactuca sativa	Lettuce	The wild varieties differ much from the average cultivated salad lettuce.
Lactuca serriola	Prickly Lettuce	Prickly lettuce is a common edible weed that is native to Europe, but can now be found from coast to coast in the United States. The name comes from the small prickles that can be found on the lower part of the stem and the midrib of the leaves. The plant is found in fields, places of waste, and roadsides. The leaves of the plant reach out towards the sun and for this reason the plant is sometimes called the Compass Plant. Prickly Lettuce can grow to be from two to five feet tall but should be harvested early on when it is a few inches high. The young leaves of the plant are very tender and make an excellent salad green. As a potherb, the plant needs little cooking and is commonly made with a sauce of melted butter or vinegar. Prickly lettuce should be harvested in spring or early summer.
Lepidium sativum	Garden cress	Used in soups, sandwiches and salads for its tangy flavour.
Manihot esculenta subsp. esculenta	Cassava	Should be always eaten boiled after disposing of the water. In some countries cassava leaves are regarded as a poor man's food and only eaten when there is nothing else..
Mentha arvensis piperascens	Japanese mint	All *Mentha* species are edible, but generally used in small quantities as garnishing or in salads
Nasturtium officinale	Watercres s	One of the most popular salad greens in certain areas, but watercress crops grown in the presence of animal waste can be a haven for parasites such as the liver fluke *Fasciola*

		hepatica.
Oxalis deppei	Iron Cross	Popular as a vegetable in Mexico for its sharp, lemony taste.
Pisonia grandis	Tree lettuce	The leaves are traditionally used as a leaf vegetable in some countries. Traditionally eaten by Maldivians in *Mas huni*.
Psoralea esculenta	Prairie turnip	The prairie turnip is a legume that was often used by American Indians located in the Great Plains. Roots of the legumes provide a valuable source of protein, minerals, and carbohydrates. Most turnips have white skin and the portion of the plant that is seen above the ground is purple, red, or green in color. The root below the surface is known as the taproot and is usually around 5-20 centimeters in diameter.
Rumex acetosa	Sorrel	Many species of Rumex are edible, but they contain a relatively high proportion of oxalic acid. Raw leaves should be eaten sparingly and leaves should preferably be used after boiling and disposing of the water.
Sauropus androgynus	*Katuk*	A traditional vegetable in some tropical countries that should be consumed in moderate quantities due to the presence of papaverine
Senna occidentalis	*Digutiyara*	Traditionally eaten in the Maldives in *Mas huni*. Leaves are finely chopped.
Senna siamea	Cassod Tree	Used in Thai cuisine in a curry named *Kaeng khilek*. Leaves are boiled and strained and the water discarded.
Spinacia oleracea	Spinach	Spinach contains a certain proportion of oxalic acid. Raw leaves should be eaten sparingly. In dishes that include large quantities, leaves should preferably be used after boiling and disposing of the water.

3.5.4-Fruit Vegetables

Vegetable-like fruits are vegetables formed from the fruits of the plants that bear them. The major fruit vegetables include:

1-*Chili peppers*

The chili pepper is the fruit of plants from the genus *Capsicum*, members of the family, Solanaceae. The substances that give chili peppers their intensity when ingested or applied topically are capsaicin (8-methyl-*N*-vanillyl-6-nonenamide) and several related chemicals, collectively called capsaicinoids.

Chili peppers originated in the Americas. After the Columbian Exchange, many cultivars of chili pepper spread across the world, used in both food and medicine. Chilies were brought to Asia by Portuguese navigators during the 16th century.

India is the world's largest producer, consumer and exporter of chili peppers. Guntur in the South Indian state of Andhra Pradesh produces 30% of all the chilies produced in India. Andhra Pradesh as a whole contributes 75% of India's chili exports.

The chili pepper features heavily in the cuisine of the Goan region of India, which was the site of a Portuguese colony (e.g., vindaloo, an Indian interpretation of a Portuguese dish). Chili peppers journeyed from India, through Central Asia and Turkey, to Hungary, where they became the national spice in the form of paprika.

The five domesticated species of chili peppers are as follows:

- *Capsicum annuum*, which includes many common varieties such as bell peppers, wax, cayenne, jalapeños, and the chiltepin
- *Capsicum frutescens*, which includes malagueta, tabasco and Thai peppers, piri piri, and Malawian Kambuzi
- *Capsicum chinense*, which includes the hottest peppers such as the naga, habanero, Datil and Scotch bonnet
- *Capsicum pubescens*, which includes the South American rocoto peppers
- *Capsicum baccatum*, which includes the South American aji peppers

Though there are only a few commonly used species, there are many cultivars and methods of preparing chili peppers that have different names for culinary use.

2-*Egg plants*

Egg plant (*Solanum melongena*) or aubergine is a species of nightshade grown for its edible fruit. It is known in South Asia, Southeast Asia and South Africa as brinjal. The fruit is widely used in cooking. As a member of the genus *Solanum*, it is related to both the tomato and the potato. It was originally domesticated from the wild nightshade species, the thorn or bitter apple, *S. incanum*, probably with two independent domestications, one in the region of South Asia, and one in East Asia.

Botanically classified as a berry, the fruit contains numerous small, soft seeds which, though edible, taste bitter because they contain nicotinoid alkaloids. Eggplant has been cultivated in southern and eastern Asia since prehistory. Different varieties of the plant produce fruit of different size, shape, and colour, though typically purple.

Egg plant is used in the cuisine of many countries. Eggplant is widely used in its native Indian cuisine, for example in *sambhar*, *dalma* (a *dal* preparation with vegetables, native to Odisha), chutney, curry, and *achaar*. Owing to its versatile nature and wide use in both everyday and festive Indian food, it is often described (under the name "baingan" or "brinjal") as the "king of vegetables". Roasted, skinned, mashed, mixed with onions, tomatoes and spices and then slow cooked gives the South Asian dish *Baingan bharta* or *gojju*. Another version of the dish, *begun-*

pora (eggplant charred or burnt), is very popular in Bangladesh and the east Indian states of Odisha and West Bengal where the pulp of the vegetable is mixed with raw chopped shallot, green chillies, salt, fresh coriander and mustard oil. Sometimes fried tomatoes and deep-fried potatoes are also added, creating a dish called *begun bhorta*. In a dish called *bharli vangi*, brinjal is stuffed with ground coconut, peanuts, and masala, and then cooked in oil.

According to FAO in 2012, production of eggplant is highly concentrated, with 90% of output coming from five countries. China is the top producer (58% of world output) and India is second (25%), followed by Iran, Egypt and Turkey. More than 1,600,000 ha are devoted to the cultivation of eggplant in the world. Nutritionally, raw eggplant is low in fat, protein, dietary fibre and carbohydrates. It also provides low amount of essential nutrients, with only manganese having a moderate percentage (11%) of the Daily Value. Minor changes in nutrient composition occur with season and environment (open field or greenhouse) of cultivation and genotype.

Bt brinjal is a transgenic eggplant that contains a gene from the soil bacterium *Bacillus thuringiensis*. This variety was designed to give the plant resistance to lepidopteran insects like the brinjal fruit and shoot borer (*Leucinodes orbonalis*) and fruit borer (*Helicoverpa armigera*). On 9 February 2010, the Environment Ministry of India imposed a moratorium on the cultivation of Bt brinjal after protests against regulatory approval of cultivated Bt brinjal in 2009, stating the moratorium would last "for as long as it is needed to establish public trust and confidence". This decision was deemed controversial, as it deviated from previous science-based, objective successes of other genetically-modified crops in India.

3- *Pod vegetables*

Pod vegetables are a type of fruit vegetables where pods are eaten, much of the time as they are still green. Such plants as green beans in the family Fabaceae, or okras in the family Malvaceae are pod vegetables.

4- *Squashes and pumpkins*

Squashes and pumpkins are members of the gourd family. Summer squashes and pumpkins originated in Mexico and Central America. Most winter squashes originated in or near the Andes in northern Argentina.

Summer squashes–zucchini, patty pans and cocozelles (Italian for vegetable marrows)–have whitish or yellow f lesh. They are the quickest to harvest–picked in summer while immature and as soon they are big enough to use. Winter squashes have orange flesh. They take longer to mature than summer squashes. Harvest winter squashes when their skins are extremely hard and their stems have started to dry out.

Pumpkins–which are simply very large hard-skinned squashes that are usually orange–are the longest to harvest mostly because they are commonly carved at Halloween and pureed for Thanksgiving pie (dish). Like other winter squashes they are picked when their skins are extremely hard and their stems are dry.

5-*Tomatoes*

The tomato is the edible, often red berry-type fruit of the nightshade *Solanum lycopersicum (*Syn. *Lycopersicon esculentum)*, commonly known as a tomato plant. The tomato is consumed in diverse ways, including raw, as an ingredient in many dishes, sauces, salads, and drinks. The species originated in the South American Andes and its use as a food originated in Mexico, and spread throughout the world following the Spanish colonization of the Americas. Its many varieties are now widely grown, sometimes in greenhouses in cooler climates. The plants typically grow to 1–3 meters (3–10 ft) in height and have a weak stem that often sprawls over the ground and vines over other plants. It is a perennial in its native habitat, although often grown outdoors in temperate climates as an annual. An average common tomato weighs approximately 100 g.

The tomato is now grown worldwide for its edible fruits, with thousands of cultivars having been selected with varying fruit types, and for optimum growth in differing growing conditions. Cultivated tomatoes vary in size, from tomberries, about 5 mm in diameter, through cherry tomatoes, about the same 1-2 cm size as the wild tomato, up to beefsteak tomatoes 10 cm or more in diameter. The most widely grown commercial tomatoes tend to be in the 5–6 cm diameter range. Most cultivars produce red fruit, but a number of cultivars with yellow, orange, pink, purple, green, black, or white fruit are also available. Multicoloured and striped fruit can also be quite striking. Tomatoes grown for canning and sauces are often elongated, 7-9 cm long and 4-5 cm diameter; they are known as plum tomatoes, and have a lower water content.

There are around 7,500 tomato varieties grown for various purposes. Heirloom tomatoes are becoming increasingly popular, particularly among home gardeners and organic producers, since they tend to produce more interesting and flavourful crops at the cost of disease resistance and productivity. In 1973, Israeli scientists developed the world's first long shelf-life commercial tomato varieties.

Tomatoes are now eaten freely throughout the world. They contain the carotene lycopene, one of the most powerful natural antioxidants. In some studies, lycopene, especially in cooked tomatoes, has been found to help prevent prostate cancer, but other research contradicts this claim. Lycopene has also been shown to improve the skin's ability to protect against harmful UV rays. Natural genetic variation in tomatoes and their wild relatives has given a genetic plethora of genes that produce lycopene, carotene, anthocyanin, and other antioxidants. Tomato varieties are available with double the normal vitamin C, high levels of anthocyanin (resulting in blue tomatoes), and two to four times normal amount of lycopene (numerous available cultivars with the high crimson gene).

Active breeding programs are ongoing by individuals, universities, corporations, and organizations. The Tomato Genetic Resource Centre, Germplasm Resources Information Network, AVRDC, Taiwan and numerous seed banks around the world store seed representing genetic variations of value to modern agriculture. These seed stocks are available for legitimate breeding and research efforts. While individual breeding efforts can produce useful results, the bulk of tomato breeding work is at universities and major agriculture-related corporations.

3.6 SUMMARY

Fruit and vegetables should be an important part of your daily diet. They are naturally good and contain vitamins and minerals that can help to keep you healthy. They can also help protect against some diseases. Fruits and vegetables contain many vitamins and minerals that are good for your health. These include vitamins A (beta-carotene), C and E, magnesium, zinc, phosphorous and folic acid. Folic acid may reduce blood levels of homocysteine, a substance that may be a risk factor for coronary heart disease. Fruits and vegetables are low in fat, salt and sugar. They are a good source of dietary fibre. As part of a well-balanced, regular diet and a healthy, active lifestyle, a high intake of fruit and vegetables can help you to: Reduce obesity and maintain a healthy weight; Lower your cholesterol, and Lower your blood pressure. Fruits are usually eaten raw and come in a wide variety of colours, shapes and flavours. Mango, apple, banana, citrus, litchi are important fruit species from Indian context. Similarly cucurbits, okra, brinjal, tubers, yams, many leafy vegetables, etc. are important vegetables in Indian context. Fruits and vegetables work as excellent substitutes in different recipes.

3.7 GLOSSARY

Achene: An achene is a kind of dry, indehiscent one-seeded fruit with a leathery pericarp that is easily separated from the seed coat.

Fruit: The edible part of a plant, shrub, or tree also developed from a flower and consisting of one or more seeds and the mass of juicy flesh that is used as food.

Grapefruit: A tropical citrus fruit that is characterized by its slightly bitter taste. Grapefruit is usually about the size of a softball and larger, has a skin that is usually yellow in color and very fleshy that ranges in color from yellowish-white to deep ruby red. Like other citrus fruits, grapefruit is an excellent source of vitamin C.

Kaffir Lime: A variety of lime that is small, round and then pointed at the end with a gnarled outer skin that emits a sharp lemon-like aroma. The Kaffir lime is not measured to be a direct member of the lime species. Instead it is categorized as one of the subspecies of citrus fruits, which are linked to the lime family. Since the flesh of the Kaffir is not edible, it is the grated peel and leaves most commonly used for foods. The rind and leaves of the lime are second-hand in recipes for curry pastes, soups, fish, shellfish, meat, poultry, vegetables, marinades, and chutneys, adding a distinct citrus smell and flavour

Lemon: An oval or round shaped bright yellow citrus fruit that is sought for its tart flavored, highly acidic juice and skin. This type is most often available are the common lemon and also the Meyer lemon. The common lemon is larger in size and very bright yellow in color and has either a smooth skin or a rough, somewhat knobby skin. The smooth skinned lemons are good for cooking or juicing while the rough skinned lemons are best for grating.

Lime: In botany, small shrub like tree (*Citrus aurantifolia*) of the family Rutaceae (rue family), one of the citrus fruit trees are similar to the lemon but more spreading and very irregular in growth. The true lime, a natural hybrid of the citron and papeda, is native to SE Asia and was introduced into S Europe, the West Indies, Mexico, Florida, and California.

Mesocarp: Mesocarp in a botanical term for the succulent and fleshy middle layer of the pericarp of drupaceous fruit, between the exocarp and very endocarp; it is usually the part of the fruit, which is eaten. The term may also refer to any fruit which is fleshy throughout.

Nuts: An edible dry fruit and seed enclosed with a hard shell that protects the kernel or meat inside. Usually, the shell is removed and discarded and only the kernel, known as the nut, inside is the item to be eaten. Nuts are available shelled and unshelled as well and the shelled nuts are available blanched or unbalanced, whole or chopped, halved, minced, raw, oil roasted, dry-roasted, salted, unsalted, and also coated with a flavoring. Nuts are also available ground as powders and butters. Some common varieties of foods referred to as nuts include: almonds, cashews, chestnuts, hazelnuts, hickory nuts, macadamias, peanuts, pecans, pine nuts, soy nuts, sunflower seeds, and also walnuts.

Stone fruits: Fruits also known as drupes - with one or more seeds surrounded by fleshy, normally edible tissue. They are often in the genus Prunes. Example: apricots, plums, cherries and mangoes.

Broccoli: Broccoli is closely related to cabbage - and it's another one of those 'greens' we're always being told to eat up. The part of a broccoli plant we normally eat is the lovely flower head - the flowers are usually green but sometimes purple. Steamed broccoli is tasty in a salad or stir-fry.

Brussels sprout: Brussels sprouts are like mini cabbages! They grow out of the ground in knobbly rows on a long tough stalk. They contain loads of vitamin C. Can you guess which country Brussels sprouts originally came from? Well, Brussels is the capital city of Belgium.

Courgette: A courgette is a type of squash and if it isn't picked early, it grows into a marrow! Courgettes grow on bushes. They look quite like cucumbers and have very soft seeds. They can be cooked with onions, tomatoes, aubergines and peppers to make ratatouille. The American name for a courgette is 'zucchini'.

Leek: These are in the same family as onion and garlic – they are Allium vegetables. Leeks need to be washed well to remove any dirt and grit between the white sections. You can boil or steam leeks to add to a recipe or stir-fry them with other vegetables. They are in season in the UK. Over the winter months and are a good source of fibre.

Yam: The skin of a yam is thick and rough like the bark of a tree! Yams are a bit like potatoes but their flesh can be white, yellow or even purple. They come from hot countries in the Caribbean and Africa, where people often mash them up and eat them in spicy stews and soups. A yam can grow to be heavier than a human adult.

3.8 SELF ASSESSMENT QUESTIONS

3.8.1 Multiple choice questions:

1. Beside India, mango is a national fruit of-

(a) China (b) Myanmar
(c) Pakistan (d) Indonesia

2- The world leader in apple production is:

(a) India (b) China
(c) USA (d) Turkey

3- Which of the following *Musa* species is a hybrid?

(a) *M. acuminata* (b) *M. Sapientum*
(c) *M. balbisiana* (d) *M. Paradisiacal*

4- The most recently discovered Australian lime is-

(a) *Clymenia sp.* (b) *Citrus reticulate*
(c) *C. maxima* (d) *Citrus* subg *Papeda*

5- Litchi is native to:

(a) India (b) China
(c) Malaysia (d) Indonesia

6- Onion is a modified stem and belongs to:

(a) Rhizome (b) Corm
(c) Bulb (d) Tuber

7- The chili peppers originated in:

(a) Americas (b) Near East
(c) Europe (d) Africa

8- Bamboos belong to-

(a) Root vegetables (b) Stem vegetables

(c) Leaf vegetables (d) Fruit vegetables

9- Tomato originated in
(a) South America (b) North America
(c) Asia (d) Europe

10-Which spice comes from a seed?
(a) Saffron (b) Cumin
(c) Clove (d) Celery

11. Flavour includes
(a) Aroma (b) Texture
(c) Taste (d) Both a and c

12. Botanical name of Black pepper is …………
(a) *Thymus vulgaris* L. (b) *Piper nigrum* L
(c) *Piper longum* L. (d) *Punica granatum* L.

13. Botanical name of Dill is …………………..
(a) *Anethum graveolens* L. (b) *Artemisia dracunculus* L.
(c) *Acorus calamus* L. (d) *Amomum subulatum* Roxb.

14. IISR a constituent body of ………..
(a) CSIR (b) ICAR
(c) CIMAP (d) ICMR

3.8.1 Answer Key: 1-(c), 2-(b), 3-(d), 4-(a), 5-(b), 6-(c), 7-(a), 8-(b), 9-(a), 10-(b), 11-(d), 12-(b), 13-(a), 14-(b)

3.9 REFERENCES

- Kostermans AJHG, Bompard JM, 1993. The Mangoes: Their Botany, Nomenclature, Horticulture and Utilization
- McGovern TW, LaWarre S (2001). "Botanical briefs: the mango tree—*Mangifera indica* L.". *Cutis* 67 (5): 365–6.
- Curtis Morgan (18 June 1995). "Mango has a long history as a culinary treat in India". *The Milwaukee Journal*. Retrieved 4 September 2013. In.lifestyle.yahoo.com. 2012-05-29. Retrieved 2013-06-14.

- Susser, Allen (2001). *The Great Mango Book*. New York: Ten Speed Press. ISBN 1-58008-204-1.
- Coart, E., Van Glabeke, S., De Loose, M., Larsen, A.S., Roldán-Ruiz, I. 2006. Chloroplast diversity in the genus *Malus*: new insights into the relationship between the European wild apple (*Malus sylvestris* (L.) Mill.) and the domesticated apple (*Malus domestica* Borkh.). *Mol. Ecol.* 15(8): 2171–82.
- Ferree, David Curtis; Ian J. Warrington (1999). *Apples: Botany, Production and Uses*. CABI Publishing. ISBN 0-85199-357-5. OCLC 182530169.
- d'Hont, A. L.; Denoeud, F.; Aury, J. M.; Baurens, F. C.; Carreel, F. O.; Garsmeur, O.; Noel, B.; Bocs, S. P.; Droc, G. T.; Rouard, M.; Da Silva, C.; Jabbari, K.; Cardi, C. L.; Poulain, J.; Souquet, M. N.; Labadie, K.; Jourda, C.; Lengellé, J.; Rodier-Goud, M.; Alberti, A.; Bernard, M.; Correa, M.; Ayyampalayam, S.; McKain, M. R.; Leebens-Mack, J.; Burgess, D.; Freeling, M.; Mbéguié-a-Mbéguié, D.; Chabannes, M. & Wicker, T. (2012). "The banana (Musa acuminata) genome and the evolution of monocotyledonous plants". *Nature* 488 (7410): 213–217. doi:10.1038/nature11241. PMID 22801500.
- Gibert, Olivier; Dufour, Dominique; Giraldo, Andrés; Sánchez, Teresa; Reynes, Max; Pain, Jean-Pierre; González, Alonso; Fernández, Alejandro & Díaz, Alberto (2009). "Differentiation between Cooking Bananas and Dessert Bananas. 1. Morphological and Compositional Characterization of Cultivated Colombian Musaceae (*Musa* sp.) in Relation to Consumer Preferences". *Journal of Agricultural and Food Chemistry* 57 (17): 7857–7869. doi:10.1021/jf901788x. PMID 19691321.
- de Langhe, Edmond & de Maret, Pierre (2004). "Tracking the banana: its significance in early agriculture". In Hather, Jon G. *The Prehistory of Food: Appetites for Change*. Routledge. p. 372. ISBN 978-0-203-20338-5.
- Liu, Y.; Heying, E.; Tanumihardjo, S. (2012). "History, Global Distribution, and Nutritional Importance of Citrus Fruits". *Comprehensive Reviews in Food Science and Food Safety* 11: 6. doi:10.1111/j.1541-4337.2012.00201.x.
- Pinchas Spiegel-Roy; Eliezer E. Goldschmidt (1996). *Biology of citrus*. Cambridge University Press. pp. 101–. ISBN 978-0-521-33321-4. Retrieved 31 July 2010.
- Kadam, S. S.; S. S. Deshpande (1995). "Lychee". In D. K. Salunkhe and S. S. Kadam. *Handbook of fruit science and technology: production, composition, storage, and processing*. New York: M. Dekker. pp. 435–443. ISBN 978-0-8247-9643-3.
- Moulherat, C.; Tengberg, M.; Haquet, J. R. M. F.; Mille, B. ̃T. (2002). "First Evidence of Cotton at Neolithic Mehrgarh, Pakistan: Analysis of Mineralized Fibres from a Copper Bead". *Journal of Archaeological Science* 29 (12): 1393. doi:10.1006/jasc.2001.0779.edit
- Maxwell, Robyn J. (2003). *Textiles of Southeast Asia: tradition, trade and transformation* (revised ed.). Tuttle Publishing. p. 410. ISBN 0-7946-0104-9.
- Hughs, S. E.; Valco, T. D.; Williford, J. R. (2008). "100 Years of Cotton Production, Harvesting, and Ginning Systems". *Transactions of the ASABE* 51 (4): 1187–98. doi:10.13031/2013.25234.edit

- Yafa, Stephen (2004). *Cotton: The Biography of a Revolutionary Fiber*. Penguin (Non-Classics). p. 16. ISBN 0-14-303722-6.
- Harries, H. C. (1978). "The evolution, dissemination and classification of Cocos nucifera L.". *The Botanical Review* 44 (3): 265–319. doi:10.1007/bf02957852.
- Harries, H.C.; Clement, C.R. (2013). "Long-distance dispersal of the coconut palm by migration within the coral atoll ecosystem". *Annals of Botany*. doi:10.1093/aob/mct293.
- Harries, H (2012). "Germination rate is the significant characteristic determining coconut palm diversity". *Annals of Botany*. doi:10.1093/aobpla/pls04.
- Lebrun, P.; Seguin, M.; Grivet, L.; Baudouin, L. (1998). "Genetic diversity in coconut (Cocos nucifera L.) revealed by restriction fragment length polymorphism (RFLP) markers". *Euphytica* 101: 103–108.
- Rivera, R.; Edwards, K. J.; Barker, J. H.; Arnold, G. M.; Ayad, G.; Hodgkin, T.; Karp, A. (1999). "Isolation and characterization of polymorphic microsatellites in Cocos nucifera L". *Genome / National Research Council Canada = Genome / Conseil national de recherches Canada* 42 (4): 668–675. doi:10.1139/gen-42-4-668. PMID 10464790.
- Tewari, D. N. 1992. *A monograph on teak (*Tectona grandis *Linn.f.).* International Book Distributors.
- Kaosa-ard, A. 1981. Teak its natural distribution and related factors. *Nat. His. Bull. Siam. Soc.*, 29: 55-74.
- Kadambi, K. (1972). Silviculture and management of Teak. Bulletin 24 School of Forestry, Stephen F. Austin State University Nacogdoches, Texas
- S. K. Mukerjee, T. Saroja & T. R. Seshadri (1971). "Dalbergichromene : a new neoflavonoid from stem-bark and heartwood of *Dalbergia sissoo*". *Tetrahedron* 27 (4): 799–803. doi:10.1016/S0040-4020(01)92474-3.
- Farjon, A. (2011). "*Pinus roxburghii*". *IUCN Red List of Threatened Species. Version 2014.3*. International Union for Conservation of Nature. Retrieved 15 February 2015.
- Stefan Willför, Mumtaz Ali, Maarit Karonen, Markku Reunanen, Mohammad Arfan & Reija Harlamow (2009). "Extractives in bark of different conifer species growing in Pakistan". *Holzforschung* 63 (5): 551–558. doi:10.1515/HF.2009.095.
- McGowan, Chris (March 5, 2008). "The Deodar Tree: the Himalayan 'Tree of God'.
- Adinarayana, D.; Seshadri, T.R. (1965). "Chemical investigation of the stem-bark of *Cedrus deodara*". *Tetrahedron* 21 (12): 3727–30. doi:10.1016/S0040-4020(01)96989-3.
- Agrawal, P.K.; Rastogi, R.P. (1982). "Two lignans from Cedrus deodara". *Phytochemistry* 21 (6): 1459. doi:10.1016/0031-9422(82)80172-6.
- Agarwal, P.K.; Rastogi, R.P. (1981). "Terpenoids from *Cedrus deodara*". *Phytochemistry* 20 (6): 1319–21. doi:10.1016/0031-9422(81)80031-3.
- Tiwari, AK; Srinivas, PV; Kumar, SP; Rao, JM (2001). "Free radical scavenging active components from Cedrus deodara". *Journal of agricultural and food chemistry* 49 (10): 4642–5. doi:10.1021/jf010573a. PMID 11600001.

- https://www.indianspices.com/export/major-itemwise-export.html.
- Kumar, N., 2015. Introduction to Spices, Plantation crops, Medicinal and Aromatic Plants. Oxford and IBH Publishing Co. PVT. LTD., New Delhi.

3.10 SUGGESTED READINGS

- Ensminger, Audrey H. et al. (1995). *The Concise Encyclopedia of Foods & Nutrition*. CRC Press. p. 651. ISBN 0-8493-4455-7.
- Litz, Richard E. (editor, 2009). *The Mango: Botany, Production and Uses*. 2nd edition. CABI. ISBN 978-1-84593-489-7
- Susser, Allen (2001). *The Great Mango Book: A Guide with Recipes*. Ten Speed Press. ISBN 978-1-58008-204-4
- Browning, F. (1999). *Apples: The Story of the Fruit of Temptation*. North Point Press. ISBN 978-0-86547-579-3
- Mabberley, D.J. / Juniper, B.E. (2009). *The Story of the Apple*. Timber Press. ISBN 978-1-60469-172-6
- Nelson, S.C.; Ploetz, R.C. & Kepler, A.K. (2006). "*Musa* species (bananas and plantains)". In Elevitch, C.R. *Species Profiles for Pacific Island Agroforestry* (PDF). Hōlualoa, Hawai'i: Permanent Agriculture Resources (PAR). Retrieved 2013-01-10.
- Office of the Gene Technology Regulator (2008). *The Biology of* Musa *L. (banana)* (PDF). Australian Government. Retrieved 2013-01-30.
- Ploetz, R.C.; Kepler, A.K.; Daniells, J. & Nelson, S.C. (2007). "Banana and Plantain: An Overview with Emphasis on Pacific Island Cultivars". In Elevitch, C.R. *Species Profiles for Pacific Island Agroforestry* (PDF). Hōlualoa, Hawai'i: Permanent Agriculture Resources (PAR). Retrieved 2013-01-10.
- Stover, R.H. & Simmonds, N.W. (1987). *Bananas* (3rd ed.). Harlow, England: Longman. ISBN 978-0-582-46357-8.
- Valmayor, Ramón V.; Jamaluddin, S.H.; Silayoi, B.; Kusumo, S.; Danh, L.D.; Pascua, O.C. & Espino, R.R.C. (2000). *Banana cultivar names and synonyms in Southeast Asia*. Los Baños, Philippines: International Network for Improvement of Banana and Plantain – Asia and the Pacific Office. ISBN 978-971-91751-2-4. Archived from the original (PDF) on 2013-01-08. Retrieved 2013-01-08.
- Andrews, A.C. (1961). "Acclimatization of citrus fruits in the Mediterranean region". *Agricultural History* **35** (1): 35–46.
- Araújo, De; Freitas, E.; de Queiroz, L. Paganucci; Machado, M.A. (2003). "What is *Citrus*? Taxonomic implications from a study of cp-DNA evolution in the tribe Citreae (Rutaceae subfamily Aurantioideae)". *Organisms Diversity & Evolution* **3** (1): 55–62. doi:10.1078/1439-6092-00058.
- Nicolosi, E.; Deng, Z.N.; Gentile, A.; La Malfa, S.; Continella, G.; Tribulato, E. (2000). "*Citrus* phylogeny and genetic origin of important species as investigated by molecular

markers". *Theoretical and Applied Genetics* **100** (8): 1155–1166. doi:10.1007/s001220051419.

- Hui, Y. H. (2008). "Lychee". *Handbook of Fruits and Fruit Processing*. New Delhi: Wiley India. pp. 606–611. ISBN 978-81-265-1788-6.
- "Cotton: The Biography of a Revolutionary Fiber" by Stephen Yafa, Publisher: Penguin USA, ISBN 978-0143037224, ISBN 0143037226
- Brown, D. Clayton. *King Cotton: A Cultural, Political, and Economic History since 1945* (University Press of Mississippi, 2011) 440 pp. ISBN 978-1-60473-798-1
- Ensminger, Audrey H. and Konlande, James E. *Foods and Nutrition Encyclopedia,* (2nd ed. CRC Press, 1993). ISBN 0-8493-8980-1
- USDA – Cotton Trade
- Moseley, W.G. and L.C. Gray (eds). *Hanging by a Thread: Cotton, Globalization and Poverty in Africa* (Ohio University Press and Nordic Africa Press, 2008). ISBN 978-0-89680-260-5
- Smith, C. Wayne and Joe Tom Cothren. *Cotton: origin, history, technology, and production* (1999) 850 pages
- True, Alfred Charles. *The cotton plant: its history, botany, chemistry, culture, enemies, and uses* (U.S. Office of Experiment Stations, 1896) online edition
- Yafa, Stephen H. *Big Cotton: How A Humble Fiber Created Fortunes, Wrecked Civilizations, and Put America on the Map* (2004) excerpt and text search
- Basu, G., A. K. Sinha, and S. N. Chattopadhyay. "Properties of Jute Based Ternary Blended Bulked Yarns". *Man-Made Textiles in India*. Vol. 48, no. 9 (Sep. 2005): 350–353. (AN 18605324)
- Chattopadhyay, S. N., N. C. Pan, and A. Day. "A Novel Process of Dyeing of Jute Fabric Using Reactive Dye". *Textile Industry of India*. Vol. 42, no. 9 (Sep. 2004): 15–22. (AN 17093709)
- Doraiswamy, I., A. Basu, and K. P. Chellamani. "Development of Fine Quality Jute Fibers". *Colourage*. Nov. 6–8, 1998, 2p. (AN TDH0624047199903296)
- Kozlowski, R., and S. Manys. "Green Fibers". The Textile Institute. *Textile Industry: Winning Strategies for the New Millennium—Papers Presented at the World Conference*. Feb. 10–13, 1999: 29 (13p). (AN TDH0646343200106392)
- Madhu, T. "Bio-Composites—An Overview". *Textile Magazine*. Vol. 43, no. 8 (Jun. 2002): 49 (2 pp). (AN TDH0656367200206816)
- Maulik, S. R. "Chemical Modification of Jute". *Asian Textile Journal*. Vol. 10, no. 7 (Jul. 2001): 99 (8 pp). (AN TDH0648424200108473)
- Moses, J. Jeyakodi, and M. Ramasamy. "Quality Improvement on Jute and Jute Cotton Materials Using Enzyme Treatment and Natural Dyeing". *Man-Made Textiles in India*. Vol. 47, no. 7 (Jul. 2004): 252–255. (AN 14075527)

- Pan, N. C., S. N. Chattopadhyay, and A. Day. "Dyeing of Jute Fabric with Natural Dye Extracted from Marigold Flower". *Asian Textile Journal*. Vol. 13, no. 7 (Jul. 2004): 80–82. (AN 15081016)
- Pan, N. C., A. Day, and K. K. Mahalanabis. "Properties of Jute". *Indian Textile Journal*. Vol. 110, no. 5 (Feb. 2000): 16. (AN TDH0635236200004885)
- Roy, T. K. G., S. K. Chatterjee, and B. D. Gupta. "Comparative Studies on Bleaching and Dyeing of Jute after Processing with Mineral Oil in Water Emulsion vis-a-vis Self-Emulsifiable Castor Oil". *Colourage*. Vol. 49, no. 8 (Aug. 2002): 27 (5 pp). (AN TDH0657901200208350)
- Shenai, V. A. "Enzyme Treatment". *Indian Textile Journal*. Vol. 114, no. 2 (Nov. 2003): 112–113. (AN 13153355)
- Srinivasan, J., A. Venkatachalam, and P. Radhakrishnan. "Small-Scale Jute Spinning: An Analysis". *Textile Magazine*. Vol. 40, no. 4 (Feb. 1999): 29. (ANTDH0624005199903254)
- Tomlinson, Jim. Carlo Morelli and Valerie Wright. *The Decline of Jute: Managing Industrial Decline* (London: Pickering and Chatto, 2011) 219 pp. ISBN 978-1-84893-124-4. focus on Dundee, Scotland
- Vijayakumar, K. A., and P. R. Raajendraa. "A New Method to Determine the Proportion of Jute in a Jute/Cotton Blend". *Asian Textile Journal*, Vol. 14, no. 5 (May 2005): 70-72. (AN 18137355)
- Adkins S.W., M. Foale and Y.M.S. Samosir (eds.) (2006). Coconut revival – new possibilities for the 'tree of life'. Proceedings of the International Coconut Forum held in Cairns, Australia, November 22–24, 2005. ACIAR Proceedings No. 125. ISBN 1-86320-515-2
- Batugal, P., V.R. Rao and J. Oliver (2005). *Coconut Genetic Resources*. Biodiversity International. ISBN 978-92-9043-629-4.
- Frison, E.A.; Putter, C.A.J.; Diekmann, M. (eds.). (1993). *Coconut*. ISBN 978-92-9043-156-5.
- International Plant Genetic Resources Institute (IPGRI). (1995). Descriptors for Coconut (*Cocos nucifera* L.). ISBN 978-92-9043-215-9.
- Mathur, P.N.; Muralidharan, K.; Parthasarathy, V.A.; Batugal, P.; Bonnot, F. (2008). *Data Analysis Manual for Coconut Researchers*. ISBN 978-92-9043-736-9.
- Salunkhe, D.K., J.K. Chavan, R.N. Adsule, and S.S. Kadam. (1992). *World Oilseeds – Chemistry, Technology, and Utilization*. Springer. ISBN 978-0-442-00112-4.

3.11 TERMINAL QUESTIONS

1. Beside India, which other countries mango is a national fruit?
2. Describe widespread uses of mango in Indian cuisines.
3. Name the wild ancestor of apple.

4. Write a note on global production of apple.
5. Write the difference between banana and plantain.
6. Name scientific names of different banana species depending on their genomic constitution.
7. Name the most important commercial banana cultivar sold in world market.
8. Describe in brief the taxonomy and systematics of the genus *Citrus*.
9. Describe the major citrus growing areas in the world
10. Describe the origin of litchi.
11. Give a general account of root, stem, fruit and leafy vegetables with special reference to India.
12. Define Bt brinjal. Why its commercial cultivation raises controversy in India?
13. What are spices? Dicuss about the classification and importance of Spices.

UNIT-4 FIBRE-YIELDING AND TIMBER-YIELDING FOREST SPECIES

Contents

4.1 OBJECTIVES

The major objectives of the present chapter are:

- To study origin, domestication, genetics, cultivation and production of fibre-yielding plants and timber yielding forest species.
- To establish link between biology and anthropology and exploiting ways humans use fibre-yielding plants and timber yielding forest species for different purposes.

4.2 INTRODUCTION

Fibre crops are field crops grown for their fibres, which are traditionally used to make paper, cloth, or rope. Botanically, the fibres harvested from many plants are bast fibres; the fibres come from the phloem tissue of the plant. The other fibre crop fibres are seed padding, leaf fibre, or other parts of the plant. Jute is bast (stem-skin) fibre; cotton and the coir, the fibre from coconut husk are seed fibres. Cotton, jute and coconut are described in this chapter.

There are over 150 species of timber which are produced in India of which Teak, Shisham, Sal, Chir-pine and deodar are important timber-yielding forest species described in this chapter.

4.3 GENERAL ACCOUNT OF FIBRE-YIELDING PLANTS

4.3.1- Cotton

Cotton (*Gossypium* spp.) is a type of flowering plant that belongs to the family Malvaceae. Cultivation of cotton started approximately 7000 years ago in Mexico (New world) and in India and Pakistan (Old world). Out of roughly 43 species of cotton, only four are cultivated on a large scale. Cotton grows in tropical and subtropical parts of Asia, Africa, Australia and America. The greatest diversity of wild cotton species is found in Mexico, followed by Australia and Africa. Cotton was independently domesticated in the Old and New Worlds. People cultivate cotton because of the seed that represent valuable source of fibres and oil. Each year, around 25 million tons of cotton are produced in the 70 countries around the world. International cotton trade is 12 billion dollars worth business. China is the greatest manufacturer of cotton in the world. The fibre is almost pure cellulose.

The use of cotton for fabric is known to date to prehistoric times; fragments of cotton fabric dated from 5000 BC have been excavated in Mexico and the Indus Valley Civilization in Ancient India. Although cultivated since antiquity, it was the invention of the cotton gin that lowered the cost of production that led to its widespread use, and it is the most widely used natural fibre cloth in clothing today.

Cotton types

There are four commercially grown species of cotton, all domesticated in antiquity:

- *Gossypium hirsutum* – upland cotton, native to Central America, Mexico, the Caribbean and southern Florida (90% of world production)
- *Gossypium barbadense* – known as extra-long staple cotton, native to tropical South America (8% of world production)
- *Gossypium arboreum* – tree cotton, native to India and Pakistan (less than 2%)
- *Gossypium herbaceum* – Levant cotton, native to southern Africa and the Arabian Peninsula (less than 2%)

History of cultivation

The two New World cotton species account for the vast majority of modern cotton production, but the two Old World species were widely used before the 1900s. While cotton fibres occur naturally in colours of white, brown, pink and green, fears of contaminating the genetics of white cotton have led many cotton-growing locations to ban the growing of coloured cotton varieties, which remain a specialty product.

Historically cotton cultivation, in Old World, became more widespread during the Indus Valley Civilization, which covered parts of modern eastern Pakistan and north-western India. Between 2000 and 1000 BC cotton became widespread across much of India. Cotton fabrics discovered in Mexico have been dated to around 5800 BC, although it is difficult to know for certain due to fibre decay.

India's cotton-processing sector gradually declined during British expansion in India and the establishment of colonial rule during the late 18th and early 19th centuries. Indian markets were increasingly forced to supply only raw cotton and were forced, by British-imposed law, to purchase manufactured textiles from Britain. The advent of the Industrial Revolution in Britain provided a great boost to cotton manufacture, as textiles emerged as Britain's leading export. From the late 18th century on, the British city of Manchester acquired the nickname *"Cottonopolis"* due to the cotton industry's omnipresence within the city, and Manchester's role as the heart of the global cotton trade.

Cultivation

Successful cultivation of cotton requires a long frost-free period, plenty of sunshine, and a moderate rainfall, usually from 600 to 1,200 mm. Soils usually need to be fairly heavy, although the level of nutrients does not need to be exceptional. In general, these conditions are met within the seasonally dry tropics and subtropics in the Northern and Southern hemispheres, but a large proportion of the cotton grown today is cultivated in areas with less rainfall that obtain the water from irrigation.

Genetically modified cotton

Genetically modified (GM) cotton was developed to reduce the heavy reliance on pesticides. GM cotton acreage in India grew at a rapid rate, increasing from 50,000 hectares in 2002 to 10.6 million hectares in 2011. The GM cotton was grown on 88% of the cotton area. This made India the country with the largest area of GM cotton in the world. Cotton has been genetically modified for resistance to glyphosate a broad-spectrum herbicide discovered by Monsanto which also sells some of the Bt cotton seeds to farmers. There are also a number of other cotton seed companies selling GM cotton around the world. About 62% of the GM cotton grown from 1996 to 2011 was insect resistant, 24% stacked product and 14% herbicide resistant.

Production and International trade

The largest producers of cotton, currently, are China and India, with annual production of about 34 million bales and 27 million bales, respectively; most of this production is consumed by their respective textile industries. The largest exporters of raw cotton are the United States, with sales of $4.9 billion, and Africa, with sales of $2.1 billion. The total international trade is estimated to be $12 billion.

In India, the states of Maharashtra (26.63%), Gujarat (17.96%) and Andhra Pradesh (13.75%) and also Madhya Pradesh are the leading cotton producing states, these states have a predominantly tropical wet and dry climate. In Pakistan, cotton is grown predominantly in the provinces of Punjab, and Sindh. The leading area of cotton production is the south Punjab, comprising the areas around. In the United States, the state of Texas led in total production as of 2004, while the state of California had the highest yield per acre.

Uses

Cotton is used to make a number of textile products. These include terrycloth for highly absorbent bath towels and robes; denim for blue jeans; cambric, popularly used in the manufacture of blue work shirts (from which we get the term "blue-collar"); and corduroy, seersucker, and cotton twill. Socks, underwear, and most T-shirts are made from cotton. Bed sheets often are made from cotton. Cotton also is used to make yarn used in crochet and knitting. Fabric also can be made from recycled or recovered cotton that otherwise would be thrown away during the spinning, weaving, or cutting process. While many fabrics are made completely of cotton, some materials blend cotton with other fibres, including rayon and synthetic fibres such as polyester. It can either be used in knitted or woven fabrics, as it can be blended with elastine to make a stretchier thread for knitted fabrics, and apparel such as stretch jeans.

In addition to the textile industry, cotton is used in fishing nets, coffee filters, tents, explosives manufacture, cotton paper, and in bookbinding. The name Egyptian cotton is broadly associated with quality products, however only a small percentage of Egyptian cotton production is actually of superior quality. Most products bearing the name are not made with the finest cottons from Egypt.

Cotton genome

A public genome sequencing effort of cotton was initiated in 2007 by a consortium of public researchers. They agreed on a strategy to sequence the genome of cultivated, tetraploid cotton. "Tetraploid" means that cultivated cotton actually has two separate genomes within its nucleus, referred to as the A and D genomes. The sequencing consortium first agreed to sequence the D-genome relative of cultivated cotton (*G. raimondii*, a wild Central American cotton species) because of its small size and limited number of repetitive elements. It is nearly one-third the number of bases of tetraploid cotton (AD), and each chromosome is only present once. The A genome of *G. arboreum* would be sequenced next. Its genome is roughly twice the size of *G. raimondii'*s. The public sector effort continues with the goal to create a high-quality, draft genome sequence from reads generated by all sources.

4.3.2- Jute

Jute, popularly called the 'Golden Fibre', is a plant that yields a fibre used for sacking and cordage. Jute is a long, soft, shiny vegetable fibre that can be spun into coarse, strong threads. It is produced from plants in the genus *Corchorus*, which was once classified with the family Tiliaceae, more recently with Malvaceae, and has now been reclassified as belonging to the family Sparrmanniaceae. The primary source of the fibre is *Corchorus olitorius*, but it is considered inferior to *Corchorus capsularis*.

Cultivation

Jute is one of the most affordable natural fibres and is second only to cotton in amount produced and variety of uses of vegetable fibres. Jute fibres are composed primarily of the plant materials cellulose and lignin. It falls into the bast fibre category (fibre collected from bast, the phloem of the plant, sometimes called the "skin”). The industrial term for jute fibre is *raw jute*. The fibers are off-white to brown, and 1- 4 m long.

Jute needs a plain alluvial soil and standing water. The suitable climate for growing jute (warm and wet) is offered by the monsoon climate, during the monsoon season. Temperatures from 20˚C to 40˚C and relative humidity of 70%–80% are favourable for successful cultivation. Jute requires 5–8 cm of rainfall weekly, and more during the sowing time. Soft water is necessary for the jute production.

White jute (*Corchorus capsularis*): Historical documents (including *Ain-e-Akbari* by Abul Fazal in 1590) state that the poor villagers of India used to wear clothes made of jute. Simple handlooms and hand spinning wheels were used by the weavers, who used to spin cotton yarns as well. History also states that Indians, especially Bengalis, used ropes and twines made of white jute (*Corchorus capsularis)* from ancient times for household and other uses. It is highly functional in carrying grains or other agricultural products.

Tossa jute (*Corchorus olitorius*): Tossa jute (*Corchorus olitorius*) is a variety thought to be native to India, and is also the world's top producer. It is grown for both fibre and culinary purposes. It is used as a herb in Middle Eastern and African countries, where the leaves are used as an ingredient in a mucilaginous potherb. It is high in protein, vitamin C, beta-carotene, calcium, and iron.

History

For centuries, jute has been an integral part of the culture of East Bengal, in the entire southwest of Bangladesh. Since the seventeenth century the British East India Company started trading in Jute. During the reign of the British Empire Jute was also used in the military. British jute barons grew rich processing jute and selling manufactured products made from jute. Dundee Jute Barons and the British East India Company set up many jute mills in Bengal and by 1895 jute industries in Bengal overtook the Scottish jute trade.

Production

Jute production is concentrated mostly in India's states of Assam, Bihar, and West Bengal, and Bangladesh. India is the world's largest producer of jute. However, India, Pakistan, and China import significant quantities of jute fibre and products from Bangladesh, as does the United Kingdom, Japan, United States, France, Spain, Côte d'Ivoire, Germany and Brazil.

Uses

Jute is in great demand due to its cheapness, softness, length, lustre and uniformity of its fibre. It is also called the 'golden fibre' due to its versatile nature. It is called the 'brown paper bag' as it is also used to store rice, wheat, grains, etc.

Jute is the second most important vegetable fibre after cotton due to its versatility. Jute is used chiefly to make cloth for wrapping bales of raw cotton, and to make sacks and coarse cloth. The fibres are also woven into curtains, chair coverings, carpets, area rugs, hessian cloth, and backing for linoleum.

Diversified byproducts from jute can be used in cosmetics, medicine, paints, and other products.

4.3.3-Coconut

Coconut tree (*Cocos nucifera*) is a plant that belongs to the family Arecaceae. The term coconut can refer to the entire coconut palm, the seed, or the fruit, which, botanically, is a drupe, not a nut. There are over 150 species of coconuts that can be found in 80 different countries throughout the world. Coconut tree grows only in the tropical climate. This plant live on the sandy soil, requires a lot of sunlight and regular rainfalls. Coconut tree does not tolerate low temperatures and low percent of humidity. Cultivated plants are prone to insect attacks which can decrease production of fruit worth of hundreds of million dollars.

Description

The coconut is known for its great versatility as seen in the many uses of its different parts and found throughout the tropics and subtropics. Coconuts are part of the daily diets of many people. Coconuts are different from any other fruits because they contain a large quantity of "water" and when immature they are known as tender-nuts or jelly-nuts and may be harvested for drinking. When mature, they still contain some water and can be used as seednuts or processed to give oil from the kernel, charcoal from the hard shell and coir from the fibrous husk. 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". When dried, the coconut flesh is called copra. The oil and milk derived from it are commonly used in cooking and frying; coconut oil is also widely used in soaps and cosmetics. The clear liquid coconut water within is potable. The husks and leaves can be used as material to make a variety of products for furnishing and decorating. The coconut also has cultural and religious significance in many societies that use it.

Cocos nucifera is a large palm, growing up to 30 m tall. Coconuts are generally classified into two general types: tall and dwarf. On very fertile land, a tall coconut palm tree can yield up to 75 fruits per year, but more often yields less than 30, mainly due to poor cultural practices.

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 coconut. Coconuts sold in the shops of nontropical countries often have had the exocarp (outermost layer) removed. The mesocarp is composed of a fibre, called coir, which has many traditional and commercial uses. The shell has three germination pores (stoma) or "eyes" that are clearly visible on its outside surface once the husk is removed. A full-sized coconut weighs about 1.44 kg. It takes around 6,000 full-grown coconuts to produce a tonne of copra. 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.

Origin, domestication and dispersal

The origin of the plant is the subject of debate. It has been hypothesized that the coconut originated in the Americas. However, more evidence exists for an Indo-Pacific origin either around Melanesia and Malesia or the Indian Ocean. The oldest fossils known of the modern coconut dating from the Eocene period from around 37 to 55 million years ago were found in Australia and India. However, older palm fossils such as some of nipa fruit have been found in the Americas.

Among modern *C. nucifera*, two major types or variants: a thick-husked, angular fruit and a thin-husked, spherical fruit with a higher proportion of endosperm reflect a trend of cultivation in *C.*

nucifera. Variants of *C. nucifera* are also categorized as Tall (var. *typical*) or Dwarf (var. *nana*). The two groups are genetically distinct, with the Dwarf variety showing a greater degree of artificial selection for ornamental traits and for early germination and fruiting. The Tall variety is outcrossing while Dwarf palms are incrossing, which has led to a much greater degree of genetic diversity within the Tall group. It is believed that the Dwarf subgroup mutated from the Tall group under human selection pressure.

The coconut has spread across much of the tropics, probably aided in many cases by seafaring people. Coconut fruit in the wild are light, buoyant and highly water resistant, and evolved to disperse significant distances via marine currents.

Cultivation and production

The coconut palm thrives on sandy soils and is highly tolerant of salinity. It prefers areas with abundant sunlight and regular rainfall (1500 mm to 2500 mm annually), which makes colonizing shorelines of the tropics relatively straightforward. Coconuts also need high humidity (70–80%) for optimum growth, which is why they are rarely seen in areas with low humidity, like the south-eastern Mediterranean or Andalusia (Spain), even where temperatures are high enough (regularly above 24 °C or 75.2 °F). However, they can be found in humid areas with low annual precipitation such as in Karachi, Pakistan, which receives only about 250 mm (9.8 in) of rainfall per year, but is consistently warm and humid. Coconut palms require warm conditions for successful growth, and are intolerant of cold.

Coconut palms are grown in more than 90 countries of the world, with a total production of 62 million tonnes per year. Most of the world production is in tropical Asia. The extent of cultivation in the tropics is threatening a number of habitats, such as mangroves. In some parts of the world (Thailand and Malaysia), trained pig-tailed macaques are used to harvest coconuts. Training schools for pig-tailed macaques still exist both in southern Thailand and in the Malaysian state of Kelantan. Competitions are held each year to find the fastest harvester.

Traditional areas of coconut cultivation in India are the states of Kerala, Tamil Nadu, Karnataka, Puducherry, Andhra Pradesh, Goa, Maharashtra, Odisha, West Bengal and the islands of Lakshadweep and Andaman and Nicobar. Four southern states combined account for almost 92% of the total production in the country: Kerala (45.22%), Tamil Nadu (26.56%), Karnataka (10.85%), and Andhra Pradesh (8.93%). Other states, such as Goa, Maharashtra, Odisha, West Bengal, and those in the northeast (Tripura and Assam) account for the remaining 8.44%. Kerala, which has the largest number of coconut trees, is famous for its coconut-based products—coconut water, copra, coconut oil, coconut cake (also called coconut meal, copra cake, or copra meal), coconut toddy, coconut shell-based products, coconut wood-based products, coconut leaves, and coir pith.

Uses

The coconut palm is grown throughout the tropics for decoration, as well as for its many culinary and nonculinary uses; virtually every part of the coconut palm can be used by humans in some manner and has significant economic value and is commonly called the "tree of life".

The culinary uses will be discussed in Unit 3 (under oilseed crops). In this section the use of coconut as coir (fibre) will only be described.

Coir (the fibre from the husk of the coconut) is used in ropes, mats, door mats, brushes, sacks, caulking for boats, and as stuffing fibre for mattresses. It is used in horticulture in potting compost, especially in orchid mix. Red coir is used in floor mats and doormats, brushes, mattresses, floor tiles and sacking. A small amount is also made into twine. Pads of curled brown coir fibre, made by needle-felting (a machine technique that mats the fibres together), are shaped and cut to fill mattresses and for use in erosion control on river banks and hillsides. A major proportion of brown coir pads are sprayed with rubber latex which bonds the fibres together (rubberised coir) to be used as upholstery padding for the automobile industry in Europe. The material is also used for insulation and packaging. The major use of white coir is in rope manufacture.

4.4 GENERAL ACCOUNT OF TIMBER-YIELD FOREST SPECIES

4.4.1-Teak

Teak is a tropical hardwood species of tree known as *Tectona grandis*. The species is placed in the family Lamiaceae. It is also known as C.P.Teak, Nagpur Teak in English. It is sometimes known as the "Burmese Teak". *Tectona grandis* is a large, deciduous tree that is dominant in mixed hardwood forests. It has small, fragrant white flowers and papery leaves that are often hairy on the lower surface. Teak wood has a leather-like smell when it is freshly milled. Teak timber is particularly valued for its durability and water resistance, and is used for boat building, exterior construction, veneer, furniture, carving, turnings, and other small wood projects.

Origin and distribution

The tree is native to south and southeast Asia, mainly India, Sri Lanka, Indonesia, Malaysia, Thailand and Burma, but is naturalized and cultivated in many countries in Africa and the Caribbean. Burma accounts for nearly one third of the world's total teak production. The other two species, *T. hamiltoniana* and *T. philippinensis*, are endemics with relatively small native distributions in Myanmar and the Philippines, respectively.

Description

Teak is a beautiful wood, valued not only for its grain quality and hue, but also for its strength and resistance to rot and mould. Teak wood has a multitude of uses, such as, the manufacture of outdoor furniture, the best available parquet flooring, sail boat decks and even for electrical insulation in harsh, dry desert conditions.

Teak can grow up to 50 m high with a girth of well over 1 m. A mature tree will have a rounded crown and, under favourable conditions, a tall clean cylindrical trunk, which is often buttressed at the base. The trees typically enjoy deep soils that are well drained and rich in calcium. They will flourish where there is an average yearly temperature of 27^{o}C and generous rainfall; although a 3 to 4 month dry season is necessary. Teak is one of the world's most valuable hardwood varieties. The rare beauty of teak, with its golden brown lustre, decorative grain and unique properties have made it one of the most demanded exotic woods of the world.

Uses

On land teak has a multitude of uses, doors, window frames, sculptures, exterior joinery, interior and exterior furniture. Teak flooring in a variety of sizes and designs enhances the beauty and the value of any room. The chemical industry recognises many applications for teak because of its durability and resistance to harsh chemicals. Teak has been used extensively in the oil fields of the Middle East as it is the only wood in the world that can withstand the harsh, dry desert conditions and not conduct electrical sparks that could cause a deadly explosion. Another outstanding feature of teak is its ability to withstand all types of climatic conditions. Teak is extremely resistant to rot and has resins (techno-quinine) that naturally repel termites.

Teak's high oil content, high tensile strength and tight grain makes it particularly suitable for outdoor furniture applications. Teak is used extensively in India to make doors and window frames, furniture, and columns and beams in old type houses. It is very resistant to termite attacks and damage caused by other insects. Mature teak fetches a very good price. It is grown extensively by forest departments of different states in forest areas.

Leaves of the teak wood tree are used in making Pellakai gatti (jackfruit dumpling), where batter is poured into a Teak leaf and is steamed. This type of usage is found in the coastal district of Udupi in the Tulunadu region in South India.

Teak has been used as a boatbuilding material for over 2000 years. In addition to relatively high strength, teak is also highly resistant to rot, fungi and mildew. In addition, teak has a relatively low shrinkage ratio, which makes it excellent for applications where it undergoes periodic changes in moisture.

The oldest and biggest teak in the world is in Uttaradit Province, Thailand. It is more than 1,500 years old. The tree is 47 metres tall, and the circumference of the trunk is 10.23 metres.

4.4.2-Shisham

Shisham (Indian rosewood, *Delbergia sissoo*) is a medium to large deciduous tree, native to India, with a light crown which reproduces by seeds and suckers. It belongs to family Fabaceae.

Description

It can grow up to a maximum of 25 m in height and 2m to 3m in diameter, but is usually smaller. It has been established in irrigated plantations, along roadsides and canals, and around farms and orchards as windbreaks. *Dalbergia sissoo* is best known internationally as a premier timber species of the rosewood genus. However, *sissoo* is also an important fuelwood, shade, shelter and fodder tree. With its multiple products, tolerance of light frosts and long dry seasons, this species deserves greater consideration for agroforestry applications.

Shisham is among the finest cabinet, furniture and veneer timbers. The heartwood is golden to dark brown, and sapwood white to pale brownish white. The heartwood is extremely durable and is resistant to dry-wood termites. Young branches and foliage form an excellent fodder with dry-matter content.

Uses

It is used for high-quality furniture, cabinets, decorative veneer, marine and aircraft grade plywood, ornamental turnery, carving, engraving, tool handles and sporting goods. Its root wood is used for tobacco pipes.

Oil obtained from the seeds is used to cure skin diseases. The powdered wood, applied externally as a paste, is reportedly used to treat leprosy and skin diseases. The roots contain tectoridin, which is used medicinally.

The calorific value of both the sapwood and heartwood is 'excellent', being reported to be 4,908 kcal/kg and 5,181 kcal/kg respectively. As a fuel wood it is grown on a 10 to 15-year rotation. The tree has excellent coppicing ability, although a loss of vigour after two or three rotations has been reported. *Shisham* wood makes excellent charcoal for heating and cooking.

Propagation

Propagation takes place most commonly by root suckers and also by seeds. The seeds remain viable for only a few months. Seeds should be soaked in water for 48 hours before sowing and 60% – 80% germination can be expected in 1–3 weeks. Seedlings require partial sun or full sun.

4.4.3-Sal

Sal *(Shorea robusta*) is a tall handsome tree providing very good quality timber and belongs to the Dipterocarpaceae family. Sal is a gregarious species and it forms the dominant composition in the forests where it occurs. It grows well in a well-drained, moist, sandy loam soil. It is a moderate to slow growing species and can attain a height upto 35 m and a girth of about 2 to 2.5 m in about 100 years under favourable conditions.

Distribution and description

Sal trees are found from Burma in the East, to Assam, Bengal, Nepal, the Deccan Plateau, going up to the foothills of the Shivaliks on the left bank of the Yamuna river. In Haryana, Sal can be found in the Morni Hills and the Kalesar forest. Sal grows well in low height plains to foothills viz. Shivaliks from 200 to 1200 meters above mean sea level. But Sal growing in Nepal and Singhbhum district of Bihar are considered to be the best variety.

The bole of Sal tree is erect and cylindrical. Sal tree is seldom completely leafless. In dry regions, however, it tends to shed practically all leaves for a short period from February to April. Fresh leaves appear during April to May depending upon the local climate.

The sap wood in Sal is of small thickness. It is whitish in colour and less durable. Heart wood is pale when freshly cut and tends to grow dark brown on exposure. It is coarse grained, hard and of fibrous structure. Annual rings are visible in young trees or on freshly cut wood. Its pores are of moderate size. These are filled with a kind of resin which makes the wood naturally durable.

Uses

Sal wood is one of the three naturally lasting timbers of the Asian subcontinent, the other two being Teak and Deodar. It weighs nearly 25 to 30 kg to a cubic foot. It is difficult to plane and more so to drive a nail in to it. It is accordingly considered most suitable for railway sleepers, piles, beams and other load bearing parts of bridge structures, wheels and bodies of carts and other similar load carriers, including motor trucks, super structure of house tops, etc. In fact Sal wood is most suitable for all such applications where strength and elasticity are foremost requirements, and where polishing is not very essential.

Sal tree when tapped yields white opaline resin which is burnt as incense in Hindu homes during religious ceremonies. It is also used for caulking boats and ships. The seeds are used for fat extraction. The oilcake, though rich in tannins (5-8%), has been used in proportions of up to 20% in concentrates for cattle without detrimental effects. As the protein remains completely undigested, the oilcake yields energy only. Sal seed cake can constitute up to 10% of poultry and pig rations without changes in performance. A kind of oil is also obtained from sal fruit which is used for burning in earthen lamps.

Religious significance

The Sal tree worshipped among Buddhists and Hindus in India and the adjoining countries. The legend has it that the famous Lumbini tract where Lord Buddha had sat for meditation and acquired salvation constituted a thick forest of Sal trees.

Regeneration

The healthy forests of Sal in their original habitat like Singhbhum (Bihar) and Doon valley (Uttarakhand) regenerate on their own. In less favourable areas these need continuous assistance for regeneration. These causes and remedies for the difficulty of Sal regeneration are an important subject of research at the National Institute of Forestry and Environment, Dehradun. They are also conducting studies into the insects and bacteria afflicting the healthy growth of Sal trees.

4.4.4-Chir-Pine

Pinus roxburghii (known as chir pine) is a species of pine native to the Himalayas, and was named after William Roxburgh. *P. roxburghii* is a large evergreen tree, which is sometimes deciduous in dry locations or dry seasons. The geographical range of occurrence of *P. roxburghii* extends from northern Pakistan, across northern India and Nepal to Bhutan. It generally occurs at lower altitudes than other pines in the Himalaya, from 500–2,000 m, occasionally up to 2,300 m. The other Himalayan pines are *Pinus wallichiana* (blue pine), *Pinus bhutanica* (Bhutan white pine), *Pinus armandii* (Chinese white pine), *Pinus gerardiana* (chilgoza pine) and *Pinus densata* (Sikang pine).

Description

P. roxburghii commonly attains a height of 45-55 m, with a diameter at breast height of 110-120 cm. The branches are very large, whorled and the crown is elongated up until reasonable maturity. As the tree matures, the crown becomes either pyramid-shaped, spreading, rounded or umbrella-shaped, with a large branch system. *P. roxburghii* is a long-lived tree. The bark is red-brown, thick and deeply fissured at the base of the trunk, thinner and flaky in the upper crown. The leaves are needle-like, in fascicles of three, very slender, 20–35 cm long, and distinctly yellowish green. The cones are ovoid conic, 12–24 cm long and 5–8 cm broad at the base when closed, green at first, ripening glossy chestnut-brown when 24 months old. They open slowly over the next year or so, or after being heated by a forest fire, to release the seeds, opening to 9–18 cm broad. The seeds are 8–9 mm long, with a 40 mm wing, and are wind-dispersed.

Uses

Chir pine is widely planted for timber in its native area, being one of the most important trees in forestry in northern Pakistan, India and Nepal. For local building purposes, the wood of this tree is the least preferred, as it is the weakest and most prone to decay when compared with other conifers. Old trees which die from fire or drought, undergo some metamorphosis in their wood due to the crystallization of the resin inside the heart wood. This makes the wood become brightly coloured and very aromatic with a brittle, glassy feel. This form of wood is very easy to ignite. Every autumn, the dried needles of this tree form a dense carpet on the forest floor, which the locals gather in large bundles to serve as bedding for their cattle, for the year round. The green needles are also used to make tiny hand brooms.

It is also tapped commercially for resin. On distillation, the resin yields an essential oil, commonly known as turpentine, and non-volatile rosin. The proportion of rosin and turpentine oil in chir pine is 75% and 22%, respectively, with 3% losses, etc. The turpentine is chiefly used as a solvent in pharmaceutical preparations, perfume industry, in manufacture of synthetic pine oil, disinfectants, insecticides and denaturants. It is one of the most important basic raw materials for the synthesis of terpene chemicals which are used in a wide variety of industries such as adhesives, paper and rubber, etc.

Chir pine rosin is principally used in paper, soap, cosmetics, paint, varnish, rubber and polish industries. Besides these, other uses include manufacture of linoleum, explosives, insecticides and disinfectants, as a flux in soldering, in brewing and in mineral beneficiation as a frothing agent.

Presently, India imports resin which is far superior in quality as well as cheaper than the indigenous one. Quality of resin depends on the pinene content. Imported resin contains 75–95% pinenes, whereas chir pine resin contains only about 25% pinenes.

4.4.5-Deodar

Deodar *(Cedrus deodara)* is a species of cedar native to the western Himalayas in eastern Afghanistan; northern Pakistan; north-western Indian Himalayas; south-westernmost Tibet (in China) and western Nepal, occurring at 1,500–3,200 m altitude. It is a large evergreen coniferous tree reaching 40–50 m tall, exceptionally 60 m with a trunk up to 3 m in diameter. It has a conic crown with level branches and drooping branchlets. The leaves are needle-like, mostly 2.5–5 cm long, occasionally up to 7 cm long, slender (1 mm thick), borne singly on long shoots, and in dense clusters of 20–30 on short shoots; they vary from bright green to blue-green in colour. The female cones are barrel-shaped, 7–13 cm long and 5–9 cm broad, and disintegrate when mature (in 12 months) to release the winged seeds. The male cones are 4–6 cm long, and shed their pollen in autumn.

Cultural significance

Among Hindus, as the etymology of deodar suggests, it is worshiped as a divine tree. Deva, the first half of the Sanskrit term, means *divine*, *deity*, or *deus*. Dāru, the second part, is cognate with (related to) the words *durum*, *druid*, *tree*, and *true*.

Forests full of Deodar trees were the favourite living place of ancient Indian sages and their families who were devoted to the Hindu God Shiva. To please Lord Shiva, the sages used to perform very difficult tapasya (meditation) practices in deodar forests. Also the ancient Hindu epics and Shaivite texts regularly mention *Darukavana*, meaning a forest of deodars, as a sacred place.

Cultivation and uses

It is widely grown as an ornamental tree, often planted in parks and large gardens for its drooping foliage. General cultivation is limited to areas with mild winters, with trees frequently killed by temperatures below about −25 °C, limiting it to USDA zone 7 and warmer for reliable growth. The most cold-tolerant trees originate in the northwest of the species' range in Kashmir and Paktia Province, Afghanistan.

Deodar is in great demand as building material because of its durability, rot-resistant character and fine, close grain, which is capable of taking a high polish. Its historical use to construct religious temples and in landscaping around temples is well recorded. Its rot-resistant character also makes it an ideal wood for constructing the well-known houseboats of Srinagar, Kashmir. In Pakistan and India, during the British colonial period, deodar wood was used extensively for construction of barracks, public buildings, bridges, canals and railway cars. Despite its durability, it is not a strong timber, and its brittle nature makes it unsuitable for delicate work where strength is required, such as chair-making.

The use of *C. deodara* in Ayurvedic medicines is well recorded. The inner wood is aromatic and used to make incense. Inner wood is distilled into essential oil. As insects avoid this tree, the essential oil is used as insect repellent on the feet of horses, cattle and camels. It also has anti-fungal properties and has some potential for control of fungal deterioration of spices during storage. The outer bark and stem are astringent. Due to its anti fungal and insect repellent properties, rooms made of Deodar wood are used to store meat and food grains like oats and wheat in Shimla, Kullu and Kinnaur district of Himachal Pradesh. In Himachal people suffering from asthma or other respiratory problems are advised to sit under a Deodar tree early in the morning.

Cedar oil is often used for its aromatic properties, especially in aromatherapy. It has a characteristic woody odour which may change somewhat in the course of drying out. The crude oils are often yellowish or darker in colour. Its applications cover soap perfumes, household sprays, floor polishes and insecticides and are also used in microscope work as a clearing oil.

The bark of *Cedrus deodara* contains large amounts of taxifolin. The wood contains cedeodarin (6-methyltaxifolin), dihydromyricetin (ampelopsin), cedrin (6-methyldihydromyricetin), cedrinoside and deodarin (3′,4′,5,6-tetrahydroxy-8-methyl dihydroflavonol). The main components of the needle essential oil include α-terpineol (30.2%), linalool (24.47%), limonene (17.01%), anethole (14.57%), caryophyllene (3.14%) and eugenol (2.14%). The deodar cedar also contains lignans and the phenolic sesquiterpene himasecolone together with isopimaric acid.

4.5 SUMMARY

Fibre crops are plants that are intentionally grown or otherwise managed for the production of fibres or fibrous materials with varied uses but not for dietary purposes. Jute is one of the most affordable natural fibers and is second only to cotton in amount produced and variety of uses of vegetable fibers. Coir, the fibre from the cocont husk also has varied uses.

India is blessed with a variety of timber-yielding tree species. Important among these are teak, Sal, Shisham, Chir-pine and deodar. Teak is moderately hard, durable and fire-resistant. It can be easily seasoned and worked. It is among the most valuable timber trees of the world and its use is limited to superior work only. Sal is hard, fibrous and close-grained. It is durable underground and water and used for railway sleepers, shipbuilding, and bridges.
Moderately hard, teak is durable and fire-resistant. It can be easily seasoned and worked. It takes up a good polish and is not attacked by white ants and dry rot. It does not corrode iron fastenings and it shrinks little. It is among the most valuable timber trees of the world and its use is limited to superior work only. Shisham wood is strong and tough. It can be easily seasoned. It is used for high quality furniture, plywoods, bridge piles, sport goods, railway sleepers and so forth. It is a very good material for decorative works and carvings. Chir-pine wood is hard and tough. It decays easily if it comes into contact with soil. It is also tapped commercially for resin. Deodar is the most important timber tree providing soft wood. It can be easily worked and it is moderately strong. It possesses distinct annual rings. It is used for making cheap furniture, railway carriages, railway sleepers, packing boxes, structural work and so forth.

4.6 GLOSSARY

Natural fibres: Natural fibres can be defined as substances produced by plants and animals that can be spun into filament, thread or rope and in a next step be woven, knitted, matted or bound.
Textile fibre: A textile or cloth is a flexible woven material consisting of a network of natural or artificial fibres often referred to as thread or yarn. Yarn is produced by spinning raw fibres of wool, flax, cotton, or other material to produce long strands.
Plant Fibre: Plant fibre is a material for many useful recipes, including Bandages. Plant Fibre is obtained by cutting vines in caves, cutting Giant Flowers from the Giant Flower Biome, cutting thick growth in Jungle Biomes, and at a lower drop rate, by harvesting crops

4.7 SELF ASSESSMENT QUESTIONS

4.7.1 Multiple choice questions

1- Bamboos belong to-
(a) Root vegetables (b) Stem vegetables
(c) Leaf vegetables (d) Fruit vegetables

2- Of the four commercially grown species, cotton species native to India is:
(a) *Gossypium hirsutum* (b) *Gossypium barbadense*
(c) *Gossypium arboreum* (d) *Gossypium herbaceum*

3- 'Golden Fibre' is a popular name of-
(a) Cotton (b) Jute
(c) Coconut (d) Flax

4- Teak is native to-
(a) South and South-east Asia (b) Africa
(c) Australia (d) South America

5-The famous Lumbini tract where Lord Buddha had sat for meditation and acquired salvation constituted a thick forest of-
(a) Teak (b) Chir Pine
(c) Sal (d) Deodar

6- The chilgoza pine is the other Himalayan pines are (blue pine), *Pinus bhutanica* (Bhutan white pine), (Chinese white pine), (chilgoza pine) and (Sikang pine).
(a) *Pinus wallichiana* (b) *Pinus armandii*
(c) *Pinus gerardiana* (d) *Pinus densata*

7- Favourite living place of ancient Indian sages and their families who were devoted to the Hindu god Shiva were the forest tress of-
(a) Deodar (b) Teak
(c) Sal (d) Chir Pine

4.7.1 Answer Key: 1-(b), 2-(c), 3-(b), 4-(a), 5-(c), 6-(c), 7-(a)

4.8 REFERENCES

- Kostermans AJHG, Bompard JM, 1993. The Mangoes: Their Botany, Nomenclature, Horticulture and Utilization
- McGovern TW, LaWarre S (2001). "Botanical briefs: the mango tree—*Mangifera indica* L.". *Cutis* 67 (5): 365–6.

- Curtis Morgan (18 June 1995). "Mango has a long history as a culinary treat in India". *The Milwaukee Journal*. Retrieved 4 September 2013. In.lifestyle.yahoo.com. 2012-05-29. Retrieved 2013-06-14.
- Susser, Allen (2001). *The Great Mango Book*. New York: Ten Speed Press. ISBN 1-58008-204-1.
- Coart, E., Van Glabeke, S., De Loose, M., Larsen, A.S., Roldán-Ruiz, I. 2006. Chloroplast diversity in the genus *Malus*: new insights into the relationship between the European wild apple (*Malus sylvestris* (L.) Mill.) and the domesticated apple (*Malus domestica* Borkh.). *Mol. Ecol.* 15(8): 2171–82.
- Ferree, David Curtis; Ian J. Warrington (1999). *Apples: Botany, Production and Uses*. CABI Publishing. ISBN 0-85199-357-5. OCLC 182530169.
- d'Hont, A. L.; Denoeud, F.; Aury, J. M.; Baurens, F. C.; Carreel, F. O.; Garsmeur, O.; Noel, B.; Bocs, S. P.; Droc, G. T.; Rouard, M.; Da Silva, C.; Jabbari, K.; Cardi, C. L.; Poulain, J.; Souquet, M. N.; Labadie, K.; Jourda, C.; Lengellé, J.; Rodier-Goud, M.; Alberti, A.; Bernard, M.; Correa, M.; Ayyampalayam, S.; McKain, M. R.; Leebens-Mack, J.; Burgess, D.; Freeling, M.; Mbéguié-a-Mbéguié, D.; Chabannes, M. & Wicker, T. (2012). "The banana (Musa acuminata) genome and the evolution of monocotyledonous plants". *Nature* 488 (7410): 213–217. doi:10.1038/nature11241. PMID 22801500.
- Gibert, Olivier; Dufour, Dominique; Giraldo, Andrés; Sánchez, Teresa; Reynes, Max; Pain, Jean-Pierre; González, Alonso; Fernández, Alejandro & Díaz, Alberto (2009). "Differentiation between Cooking Bananas and Dessert Bananas. 1. Morphological and Compositional Characterization of Cultivated Colombian Musaceae (*Musa* sp.) in Relation to Consumer Preferences". *Journal of Agricultural and Food Chemistry* 57 (17): 7857–7869. doi:10.1021/jf901788x. PMID 19691321.
- de Langhe, Edmond & de Maret, Pierre (2004). "Tracking the banana: its significance in early agriculture". In Hather, Jon G. *The Prehistory of Food: Appetites for Change*. Routledge. p. 372. ISBN 978-0-203-20338-5.
- Liu, Y.; Heying, E.; Tanumihardjo, S. (2012). "History, Global Distribution, and Nutritional Importance of Citrus Fruits". *Comprehensive Reviews in Food Science and Food Safety* 11: 6. doi:10.1111/j.1541-4337.2012.00201.x.
- Pinchas Spiegel-Roy; Eliezer E. Goldschmidt (1996). *Biology of citrus*. Cambridge University Press. pp. 101–. ISBN 978-0-521-33321-4. Retrieved 31 July 2010.
- Kadam, S. S.; S. S. Deshpande (1995). "Lychee". In D. K. Salunkhe and S. S. Kadam. *Handbook of fruit science and technology: production, composition, storage, and processing*. New York: M. Dekker. pp. 435–443. ISBN 978-0-8247-9643-3.
- Moulherat, C.; Tengberg, M.; Haquet, J. R. M. F.; Mille, B. T. (2002). "First Evidence of Cotton at Neolithic Mehrgarh, Pakistan: Analysis of Mineralized Fibres from a Copper Bead". *Journal of Archaeological Science* 29 (12): 1393. doi:10.1006/jasc.2001.0779.edit
- Maxwell, Robyn J. (2003). *Textiles of Southeast Asia: tradition, trade and transformation* (revised ed.). Tuttle Publishing. p. 410. ISBN 0-7946-0104-9.

- Hughs, S. E.; Valco, T. D.; Williford, J. R. (2008). "100 Years of Cotton Production, Harvesting, and Ginning Systems". *Transactions of the ASABE* 51 (4): 1187–98. doi:10.13031/2013.25234.edit
- Yafa, Stephen (2004). *Cotton: The Biography of a Revolutionary Fiber*. Penguin (Non-Classics). p. 16. ISBN 0-14-303722-6.
- Harries, H. C. (1978). "The evolution, dissemination and classification of Cocos nucifera L.". *The Botanical Review* 44 (3): 265–319. doi:10.1007/bf02957852.
- Harries, H.C.; Clement, C.R. (2013). "Long-distance dispersal of the coconut palm by migration within the coral atoll ecosystem". *Annals of Botany*. doi:10.1093/aob/mct293.
- Harries, H (2012). "Germination rate is the significant characteristic determining coconut palm diversity". *Annals of Botany*. doi:10.1093/aobpla/pls04.
- Lebrun, P.; Seguin, M.; Grivet, L.; Baudouin, L. (1998). "Genetic diversity in coconut (Cocos nucifera L.) revealed by restriction fragment length polymorphism (RFLP) markers". *Euphytica* 101: 103–108.
- Rivera, R.; Edwards, K. J.; Barker, J. H.; Arnold, G. M.; Ayad, G.; Hodgkin, T.; Karp, A. (1999). "Isolation and characterization of polymorphic microsatellites in Cocos nucifera L". *Genome / National Research Council Canada = Genome / Conseil national de recherches Canada* 42 (4): 668–675. doi:10.1139/gen-42-4-668. PMID 10464790.
- Tewari, D. N. 1992. *A monograph on teak (*Tectona grandis *Linn.f.).* International Book Distributors.
- Kaosa-ard, A. 1981. Teak its natural distribution and related factors. *Nat. His. Bull. Siam. Soc.*, 29: 55-74.
- Kadambi, K. (1972). Silviculture and management of Teak. Bulletin 24 School of Forestry, Stephen F. Austin State University Nacogdoches, Texas
- S. K. Mukerjee, T. Saroja & T. R. Seshadri (1971). "Dalbergichromene : a new neoflavonoid from stem-bark and heartwood of *Dalbergia sissoo*". *Tetrahedron* 27 (4): 799–803. doi:10.1016/S0040-4020(01)92474-3.
- Farjon, A. (2011). "*Pinus roxburghii*". *IUCN Red List of Threatened Species. Version 2014.3*. International Union for Conservation of Nature. Retrieved 15 February 2015.
- Stefan Willför, Mumtaz Ali, Maarit Karonen, Markku Reunanen, Mohammad Arfan & Reija Harlamow (2009). "Extractives in bark of different conifer species growing in Pakistan". *Holzforschung* 63 (5): 551–558. doi:10.1515/HF.2009.095.
- McGowan, Chris (March 5, 2008). "The Deodar Tree: the Himalayan 'Tree of God'.
- Adinarayana, D.; Seshadri, T.R. (1965). "Chemical investigation of the stem-bark of *Cedrus deodara*". *Tetrahedron* 21 (12): 3727–30. doi:10.1016/S0040-4020(01)96989-3.
- Agrawal, P.K.; Rastogi, R.P. (1982). "Two lignans from Cedrus deodara". *Phytochemistry* 21 (6): 1459. doi:10.1016/0031-9422(82)80172-6.
- Agarwal, P.K.; Rastogi, R.P. (1981). "Terpenoids from *Cedrus deodara*". *Phytochemistry* 20 (6): 1319–21. doi:10.1016/0031-9422(81)80031-3.

- Tiwari, AK; Srinivas, PV; Kumar, SP; Rao, JM (2001). "Free radical scavenging active components from Cedrus deodara". *Journal of agricultural and food chemistry* 49 (10): 4642–5. doi:10.1021/jf010573a. PMID 11600001.

4.9 SUGGESTED READINGS

- Ensminger, Audrey H. et al. (1995). *The Concise Encyclopedia of Foods & Nutrition*. CRC Press. p. 651. ISBN 0-8493-4455-7.
- Litz, Richard E. (editor, 2009). *The Mango: Botany, Production and Uses*. 2nd edition. CABI. ISBN 978-1-84593-489-7
- Susser, Allen (2001). *The Great Mango Book: A Guide with Recipes*. Ten Speed Press. ISBN 978-1-58008-204-4
- Browning, F. (1999). *Apples: The Story of the Fruit of Temptation*. North Point Press. ISBN 978-0-86547-579-3
- Mabberley, D.J. / Juniper, B.E. (2009). *The Story of the Apple*. Timber Press. ISBN 978-1-60469-172-6
- Nelson, S.C.; Ploetz, R.C. & Kepler, A.K. (2006). "*Musa* species (bananas and plantains)". In Elevitch, C.R. *Species Profiles for Pacific Island Agroforestry* (PDF). Hōlualoa, Hawai'i: Permanent Agriculture Resources (PAR). Retrieved 2013-01-10.
- Office of the Gene Technology Regulator (2008). *The Biology of* Musa *L. (banana)* (PDF). Australian Government. Retrieved 2013-01-30.
- Ploetz, R.C.; Kepler, A.K.; Daniells, J. & Nelson, S.C. (2007). "Banana and Plantain: An Overview with Emphasis on Pacific Island Cultivars". In Elevitch, C.R. *Species Profiles for Pacific Island Agroforestry* (PDF). Hōlualoa, Hawai'i: Permanent Agriculture Resources (PAR). Retrieved 2013-01-10.
- Stover, R.H. & Simmonds, N.W. (1987). *Bananas* (3rd ed.). Harlow, England: Longman. ISBN 978-0-582-46357-8.
- Valmayor, Ramón V.; Jamaluddin, S.H.; Silayoi, B.; Kusumo, S.; Danh, L.D.; Pascua, O.C. & Espino, R.R.C. (2000). *Banana cultivar names and synonyms in Southeast Asia*. Los Baños, Philippines: International Network for Improvement of Banana and Plantain – Asia and the Pacific Office. ISBN 978-971-91751-2-4. Archived from the original (PDF) on 2013-01-08. Retrieved 2013-01-08.
- Andrews, A.C. (1961). "Acclimatization of citrus fruits in the Mediterranean region". *Agricultural History* **35** (1): 35–46.
- Araújo, De; Freitas, E.; de Queiroz, L. Paganucci; Machado, M.A. (2003). "What is *Citrus*? Taxonomic implications from a study of cp-DNA evolution in the tribe Citreae (Rutaceae subfamily Aurantioideae)". *Organisms Diversity & Evolution* **3** (1): 55–62. doi:10.1078/1439-6092-00058.

- Nicolosi, E.; Deng, Z.N.; Gentile, A.; La Malfa, S.; Continella, G.; Tribulato, E. (2000). "*Citrus* phylogeny and genetic origin of important species as investigated by molecular markers". *Theoretical and Applied Genetics* **100** (8): 1155–1166. doi:10.1007/s001220051419.
- Hui, Y. H. (2008). "Lychee". *Handbook of Fruits and Fruit Processing*. New Delhi: Wiley India. pp. 606–611. ISBN 978-81-265-1788-6.
- "Cotton: The Biography of a Revolutionary Fiber" by Stephen Yafa, Publisher: Penguin USA, ISBN 978-0143037224, ISBN 0143037226
- Brown, D. Clayton. *King Cotton: A Cultural, Political, and Economic History since 1945* (University Press of Mississippi, 2011) 440 pp. ISBN 978-1-60473-798-1
- Ensminger, Audrey H. and Konlande, James E. *Foods and Nutrition Encyclopedia,* (2nd ed. CRC Press, 1993). ISBN 0-8493-8980-1
- USDA – Cotton Trade
- Moseley, W.G. and L.C. Gray (eds). *Hanging by a Thread: Cotton, Globalization and Poverty in Africa* (Ohio University Press and Nordic Africa Press, 2008). ISBN 978-0-89680-260-5
- Smith, C. Wayne and Joe Tom Cothren. *Cotton: origin, history, technology, and production* (1999) 850 pages
- True, Alfred Charles. *The cotton plant: its history, botany, chemistry, culture, enemies, and uses* (U.S. Office of Experiment Stations, 1896) online edition
- Yafa, Stephen H. *Big Cotton: How A Humble Fiber Created Fortunes, Wrecked Civilizations, and Put America on the Map* (2004) excerpt and text search
- Basu, G., A. K. Sinha, and S. N. Chattopadhyay. "Properties of Jute Based Ternary Blended Bulked Yarns". *Man-Made Textiles in India*. Vol. 48, no. 9 (Sep. 2005): 350–353. (AN 18605324)
- Chattopadhyay, S. N., N. C. Pan, and A. Day. "A Novel Process of Dyeing of Jute Fabric Using Reactive Dye". *Textile Industry of India*. Vol. 42, no. 9 (Sep. 2004): 15–22. (AN 17093709)
- Doraiswamy, I., A. Basu, and K. P. Chellamani. "Development of Fine Quality Jute Fibers". *Colourage*. Nov. 6–8, 1998, 2p. (AN TDH0624047199903296)
- Kozlowski, R., and S. Manys. "Green Fibers". The Textile Institute. *Textile Industry: Winning Strategies for the New Millennium—Papers Presented at the World Conference*. Feb. 10–13, 1999: 29 (13p). (AN TDH0646343200106392)
- Madhu, T. "Bio-Composites—An Overview". *Textile Magazine*. Vol. 43, no. 8 (Jun. 2002): 49 (2 pp). (AN TDH0656367200206816)
- Maulik, S. R. "Chemical Modification of Jute". *Asian Textile Journal*. Vol. 10, no. 7 (Jul. 2001): 99 (8 pp). (AN TDH0648424200108473)
- Moses, J. Jeyakodi, and M. Ramasamy. "Quality Improvement on Jute and Jute Cotton Materials Using Enzyme Treatment and Natural Dyeing". *Man-Made Textiles in India*. Vol. 47, no. 7 (Jul. 2004): 252–255. (AN 14075527)

- Pan, N. C., S. N. Chattopadhyay, and A. Day. "Dyeing of Jute Fabric with Natural Dye Extracted from Marigold Flower". *Asian Textile Journal*. Vol. 13, no. 7 (Jul. 2004): 80–82. (AN 15081016)
- Pan, N. C., A. Day, and K. K. Mahalanabis. "Properties of Jute". *Indian Textile Journal*. Vol. 110, no. 5 (Feb. 2000): 16. (AN TDH0635236200004885)
- Roy, T. K. G., S. K. Chatterjee, and B. D. Gupta. "Comparative Studies on Bleaching and Dyeing of Jute after Processing with Mineral Oil in Water Emulsion vis-a-vis Self-Emulsifiable Castor Oil". *Colourage*. Vol. 49, no. 8 (Aug. 2002): 27 (5 pp). (AN TDH0657901200208350)
- Shenai, V. A. "Enzyme Treatment". *Indian Textile Journal*. Vol. 114, no. 2 (Nov. 2003): 112–113. (AN 13153355)
- Srinivasan, J., A. Venkatachalam, and P. Radhakrishnan. "Small-Scale Jute Spinning: An Analysis". *Textile Magazine*. Vol. 40, no. 4 (Feb. 1999): 29. (ANTDH0624005199903254)
- Tomlinson, Jim. Carlo Morelli and Valerie Wright. *The Decline of Jute: Managing Industrial Decline* (London: Pickering and Chatto, 2011) 219 pp. ISBN 978-1-84893-124-4. focus on Dundee, Scotland
- Vijayakumar, K. A., and P. R. Raajendraa. "A New Method to Determine the Proportion of Jute in a Jute/Cotton Blend". *Asian Textile Journal*, Vol. 14, no. 5 (May 2005): 70-72. (AN 18137355)
- Adkins S.W., M. Foale and Y.M.S. Samosir (eds.) (2006). Coconut revival – new possibilities for the 'tree of life'. Proceedings of the International Coconut Forum held in Cairns, Australia, November 22–24, 2005. ACIAR Proceedings No. 125. ISBN 1-86320-515-2
- Batugal, P., V.R. Rao and J. Oliver (2005). *Coconut Genetic Resources*. Biodiversity International. ISBN 978-92-9043-629-4.
- Frison, E.A.; Putter, C.A.J.; Diekmann, M. (eds.). (1993). *Coconut*. ISBN 978-92-9043-156-5.
- International Plant Genetic Resources Institute (IPGRI). (1995). Descriptors for Coconut (*Cocos nucifera* L.). ISBN 978-92-9043-215-9.
- Mathur, P.N.; Muralidharan, K.; Parthasarathy, V.A.; Batugal, P.; Bonnot, F. (2008). *Data Analysis Manual for Coconut Researchers*. ISBN 978-92-9043-736-9.
- Salunkhe, D.K., J.K. Chavan, R.N. Adsule, and S.S. Kadam. (1992). *World Oilseeds – Chemistry, Technology, and Utilization*. Springer. ISBN 978-0-442-00112-4.

4.10 TERMINAL QUESTIONS

4.10.1 Short Answer type Questions

1. What is a natural fibre?
2. What is a textile fibre?

3. What are the three stages in the making of textile materials?
4. Various uses of chir pine.
5. The religious significance of sal and deodar trees.

4.10.2 Long Answer type Questions

1. Name the commercially grown species of cotton and write a note on its domestication.
2. Define GM cotton. Which country in the world is the largest producer of GM cotton?
3. Describe the cultural significance of jute in India.
4. Describe the importance of coconut as a fibre crop.
5. Give a general account of timber yielding plants of India.
6. Deodar tree is native to which part of the world? What is its cultural significance?

UNIT-5 MEDICINAL AND WILD EDIBLE PLANTS, OILS AND BEVERAGES

Contents

5.1 OBJECTIVES

The major objectives of the present chapter are:

- To study origin, domestication, genetics, cultivation and production of medicinal plants and wild edible plants, oils and beverages.
- To establish link between biology and anthropology and exploiting ways humans use medicinal plants and wild edible plants, oils and beverages for medicinal, food and other purposes.

5.2 INTRODUCTION

Before there was modern-day medicine and its pharmacopeia of synthetic drugs, there were plants, and ancient civilizations knew how to use them strategically to treat common ailments and even life-threatening diseases. The ancient Egyptian Ebers Papyrus details 700 medicinal herbs and how to use them. The Greek Corpus Hippocraticum from the 16th century BC also details the use of herbal medicine. Later, during the 1800s and early 1900s, the knowledge of herbal medicine was passed down from one generation to the next. Typically, the woman of the house was well versed in the use of herbs for healing, and would act as the family's physician not only to treat illnesses but also to prepare various herbal wellness tonics and other remedies. Today, the World Health Organization (WHO) estimates that 80 percent of the world's population still uses traditional remedies, including plants, as their primary health care tools. Medicinal and other uses of *Aconitum*, *Atropa*, *Cinchona*, *Rauwolfia* and *Ephedra* are described here. Species that are edible in the wild but have not been domesticated or cultivated are referred to as "wild edible plants" (WEPs). In times of crop shortages, WEPs continue to be important in safeguarding food security and sovereignty as well as the welfare of limited households.

Oil-bearing crops or oil crops include both annual (usually called oilseeds) and perennial plants whose seeds, fruits or mesocarp and nuts are valued mainly for the edible or industrial oils that are extracted from them. Dessert and table nuts, although rich in oil, are listed under "Nuts". The important oil crops included in this chapter are castor, coconut, linseed, mustard and groundnut. Only 5-6 percent of the world production of oil crops is used for seed (oilseeds) and animal feed, while about 8 percent is used for food. The remaining 86 percent is processed into oil. The fat content of oil crops varies widely. Fat content ranges from as low as 10-15 percent of the weight of coconuts to over 50 percent of the weight of groundnut, mustard or castor seeds. Carbohydrates, mainly polysaccharides, range from 15 to 30 percent in the oilseeds, but are generally lower in other oil-bearing crops. The protein content is also high in some oilseeds.

The beverages are liquids, specifically prepared for human consumption. In addition to basic needs, beverages form a part of the culture of human society. Important beverage crops included in this chapter are tea, coffee and cocoa.

5.3 MEDICINAL PLANTS

5.3.1-*Aconitum*

Aconitum, also known as aconite, monkshood, wolf's bane, leopard's bane, mouse bane, women's bane, devil's helmet, Queen of all Poisons, or blue rocket, is a genus of over 250 species of flowering plants belonging to the family Ranunculaceae. These herbaceous perennial plants are chiefly native to the mountain meadows of the northern hemisphere. Most species are extremely poisonous and must be dealt carefully. The name may reflect that toxins extracted from the plant were historically used to kill wolves, hence the name *wolf's bane*. It has been noted that the symptoms of aconite poisoning in humans bear some passing similarity to those of rabies: frothy saliva, impaired vision, vertigo, and finally a coma.

Origin and cultivation

Aconitum napellus is endemic to western and central Europe. Plants native to Asia and North America formerly listed as *A. napellus* are now regarded as separate species. *A. napellus* is grown in gardens in temperate zones for their spiky inflorescences that are showy in early-midsummer, and their attractive foliage. There are white and rose coloured forms in cultivation too. The cultivar 'Spark's Variety' has gained the Royal Horticultural Society's Award of Garden Merit. Nine subspecies of *A. napellus* are accepted by the *Flora Europaea*.

Uses and toxicology

Several species of *Aconitum* have been used as arrow poisons. The Minaro in Ladakh use *A. napellus* on their arrows to hunt ibex, while the Ainu in Japan used a species of *Aconitum* to hunt bear. The Chinese also used *Aconitum* poisons both for hunting and for warfare. Aconitum poisons were used by the Aleuts of Alaska's Aleutian Islands for hunting whales. Usually, one man in a kayak armed with a poison-tipped lance would hunt the whale, paralyzing it with the poison and causing it to drown.

Like other species in the genus, *A. napellus* contains several poisonous compounds, including enough cardiac poison that it was used on spears and arrows for hunting and battle in ancient times. *A. napellus* has a long history of use as a poison, with cases going back thousands of years. During the ancient Roman period of European history, the plant was often used to eliminate criminals and enemies, and by the end of the period it was banned and anyone growing *A. napellus* could have been legally sentenced to death. Aconites have been used more recently in murder plots; they contain the chemical alkaloids aconitine, mesaconitine, hypaconitine and jesaconitine, which are highly toxic.

Marked symptoms may appear almost immediately, usually not later than one hour, and with large doses death is almost instantaneous. The initial signs are gastrointestinal including nausea, vomiting, and diarrhoea. This is followed by a sensation of burning, tingling, and numbness in the mouth and face, and of burning in the abdomen. In severe poisonings pronounced motor weakness occurs and cutaneous sensations of tingling and numbness spread to the limbs. Cardiovascular features include hypotension, sinus bradycardia, and ventricular arrhythmias. Other features may include sweating, dizziness, difficulty in breathing, headache, and confusion. The main causes of death are ventricular arrhythmias and asystole, paralysis of the heart or of the respiratory centre. Aconite has long been used in traditional Chinese medicine and Ayurveda (Hindu traditional medicine).

5.3.2-*Atropa*

Atropa is a genus of flowering plants belonging to the family, Solanaceae. Its best-known member is the deadly Nightshade (*A. belladonna*). *A. belladonna*, commonly known as belladonna or deadly nightshade, is a perennial herbaceous plant, native to Europe, North Africa, Western Asia, and some parts of Canada and the United States. The foliage and berries are extremely toxic, containing tropane alkaloids. These toxins include scopolamine and hyoscyamine, which cause a bizarre delirium and hallucinations, and are also used as pharmaceutical anticholinergics. The drug atropine is derived from the plant.

Uses and toxicity

It has a long history of use as a medicine, cosmetic, and poison. Before the Middle Ages, it was used as an anaesthetic for surgery; the ancient Romans used it as a poison; and, predating this, it was used to make poison-tipped arrows. The genus name *Atropa* comes from Atropos, one of the three Fates in Greek mythology, and the name "belladonna" is derived from Italian and means "beautiful lady" because the herb was used in eye-drops by women to dilate the pupils of the eyes to make them appear seductive.

The active agents in belladonna, atropine, hyoscine (scopolamine), and hyoscyamine, have anticholinergic properties. The symptoms of belladonna poisoning include dilated pupils, sensitivity to light, blurred vision, tachycardia, loss of balance, staggering, headache, rash, flushing, severely dry mouth and throat, slurred speech, urinary retention, constipation, confusion, hallucinations, delirium, and convulsions. The antidote for belladonna poisoning is physostigmine or pilocarpine, the same as for atropine.

A. belladonna is also toxic to many domestic animals, causing narcosis and paralysis. However, cattle and rabbits eat the plant seemingly without suffering harmful effects. In humans, its anticholinergic properties will cause the disruption of cognitive capacities, such as memory and learning.

Belladonna has been used in herbal medicine for centuries as a pain reliever, muscle relaxer, and anti-inflammatory, and to treat menstrual problems, peptic ulcer disease, histaminic reaction, and motion sickness. Belladonna tinctures, decoctions, and powders, as well as alkaloid salt mixtures, are still produced for pharmaceutical use. The alkaloids are compounded with phenobarbital and/or kaolin and pectin for use in various functional gastrointestinal disorders. The combination of belladonna and opium, in powder, tincture, or alkaloid form, is particularly useful by mouth or as a suppository for diarrhoea and some forms of visceral pain; it can be made by a compounding pharmacist, and may be available as a manufactured fixed combination product in some countries.

Scopolamine is used as the hydrobromide salt for GI complaints and motion sickness, and to potentiate the analgesic and anxiolytic effects of opioid analgesics. It was formerly used in a painkiller called "twilight sleep" in childbirth.

Scientific evidence to recommend the use of *A. belladonna* in its natural form for any condition is insufficient, although some of its components, in particular *l*-atropine, which was purified from belladonna in the 1830s, have accepted medical uses. Belladonna preparations are used in homeopathy as alleged treatments for various conditions. *A. belladonna* and related plants, such as jimson weed (*Datura stramonium*), have occasionally been used as recreational drugs because of the vivid hallucinations and delirium they produce.

5.3.3-*Cinchona*

Cinchona, common name quina, is a genus of about 25 recognized species in the family Rubiaceae, native to the tropical Andes forests of western South America. A few species are reportedly naturalized in Central America, Jamaica, French Polynesia, Sulawesi, Saint Helena in the South Atlantic, and São Tome & Principe off the coast of tropical Africa. A few species are used as medicinal plants, known as sources for quinine and other compounds.

Taxonomy

The name of the genus is due to Linnaeus, who named the tree in 1742 after the Second Countess of Chinchón, the wife of a viceroy of Peru, who, in 1638 (according to accounts at the time, now disparaged) was introduced by native Quechua healers to the medicinal properties of cinchona bark. Stories of the medicinal properties of this bark, however, are perhaps noted in journals as far back as the 1560s-1570s. It is the national tree of Ecuador and Peru.

Cultivation and medicinal uses

The medicinal properties of the cinchona tree were originally discovered by the Quechua peoples of Peru, Bolivia, and Ecuador, and long cultivated by them as a muscle relaxant to abate shivering due to low body temperatures, and symptoms of Malaria. The Countess of Chinchon contracted malaria and native people persuaded her to immerse in a small pond beneath a tree; the water was bitter (due to the quinine contents). After a few days the Countess was cured of malaria. When the scientific botanical classification was determined, the tree was named after the Chinchon Countess, *Chinchona*. Later the Jesuit Brother Agostino Salumbrino (1561–1642), an apothecary by training who lived in Loja (Ecuador) and Lima, observed the Quechua using the quinine-containing bark of the cinchona tree for the purpose of curing malaria. While its effect in treating malaria (and related malaria-induced shivering) was entirely unrelated to the plant's efficacy in controlling shivering from cold, it was nevertheless the correct medicine for malaria. The use of the “fever tree” bark was introduced into European medicine by Jesuit missionaries (Jesuit's bark). Jesuit Bernabé Cobo (1582–1657), who explored Mexico and Peru, is credited with taking cinchona bark to Europe. He brought the bark from Lima to Spain, and afterwards to Rome and other parts of Italy, in 1632. To maintain their monopoly on cinchona bark, Peru and surrounding countries began outlawing the export of cinchona seeds and saplings beginning in the early 19th century.

In the 19th century, the plant's seeds and cuttings were smuggled out for new cultivation at cinchona plantations in colonial regions of tropical Asia, notably by the British to the British Raj and Ceylon (present day India and Sri Lanka), and by the Dutch to Java in the Dutch East Indies (present day Indonesia).

Chemistry

As a medicinal herb, cinchona bark is stripped from the tree, dried, and powdered for medicinal uses. The bark is medicinally active, containing a variety of alkaloids including the antimalarial compound quinine and the antiarrhythmic quinidine. Although the use of the bark has been largely superseded by more effective modern medicines, cinchona is the only economically practical source of quinine, a drug that is still recommended for the treatment of Malaria.

English King Charles II called upon Robert Talbor, who had become famous for his miraculous malaria cure. Because at that time the bark was in religious controversy, Talbor gave the king the bitter bark decoction in great secrecy. The treatment gave the king complete relief from the malaria fever. In return, Talbor was offered membership of the prestigious Royal College of Physicians. In 1679, Talbor was called by the King of France, Louis XIV, whose son was suffering from malaria fever. After a successful treatment, Talbor was rewarded by the king with 3,000 gold coins and a lifetime pension for this prescription. Talbor, however, was asked to keep the entire episode secret. After Talbor's death, the French king found this formula: seven grams of rose leaves, two ounces of lemon juice and a strong decoction of the cinchona bark served with wine. Wine was used because some alkaloids of the cinchona bark are not soluble in water, but are soluble in the ethanol in wine.

The birth of homeopathy was based on cinchona bark testing. The founder of homeopathy, Samuel Hahnemann, when translating William Cullen's *Materia medica*, noticed Cullen had written that Peruvian bark was known to cure intermittent fevers. Hahnemann took daily a large, rather than homeopathic, dose of Peruvian bark. After two weeks, he said he felt malaria-like symptoms. This idea of "like cures like" was the starting point of his writings on homeopathy. Hahnemann's symptoms are believed to be the result of a hypersensitivity to cinchona bark on his part.

The bark was very valuable to Europeans in expanding their access to and exploitation of resources in far-off colonies, and at home. Bark gathering was often environmentally destructive, destroying huge expanses of trees for their bark, with difficult conditions for low wages that did not allow the indigenous bark gatherers to settle debts even upon death.

British expedition to South America led by Clements Markham brought back smuggled cinchona seeds and plants, which were introduced in several areas of the British Raj in India and Sri Lanka. In Sri Lanka, it was planted in the Hakgala Botanical Garden in January 1861. James Taylor, the pioneer of tea planting in Sri Lanka, was one of the pioneers of cinchona cultivation. By 1883, about 64,000 acres were in cultivation in Sri Lanka, with exports reaching a peak of 15 million pounds in 1886. It was also cultivated by British in 1862 in the hilly terrain of Darjeeling District of West Bengal, India. There is a factory and plantation named after Cinchona at Mungpoo, Darjeeling, West Bengal. The factory is called a Govt. Quinine Factory. Cultivation of Cinchona continues at places like Mungpoo, Munsong, Latpanchar, and Rongo under the supervision of the government of West Bengal's Directorate of Cinchona & Other Medicinal Plants.

There are at least 31 species acknowledged by botanists, and the list is growing, on account of the tendency of the various trees to hybridize. Resolution of other species is awaiting results of DNA studies. Several species formerly in the genus are now placed in *Cascarilla*.

5.3.4-*Rauwolfia*

Rauvolfia (also spelled *Rauwolfia*) is a genus of evergreen trees and shrubs in the dogbane family, Apocynaceae. The genus is named to honour Leonhard Rauwolf. The genus can mainly be found in tropical regions of Africa, Asia, Latin America, and various oceanic islands with over 75 species reported. *R. serpentina* (L.) Benth. *ex* Kurz, , or Indian snakeroot or *sarpagandha*, is native to the Indian Subcontinent and East Asia (from India to Indonesia).

Chemical constituents

Rauvolfia serpentina plant contains more than 50 different alkaloids which belong to the monoterpenoid indole alkaloid family. The major alkaloids are ajmaline, ajmalicine, ajmalimine, deserpidine, indobine, indobinine, reserpine, reserpiline, rescinnamine, rescinnamidine, serpentine, serpentinine and yohimbine.

Medicinal uses

The plant is known for curing various disorders because of the presence of alkaloids, carbohydrates, flavonoids, glycosides, phlobatannins, phenols, resins, saponins, tannins and terpenes.

The extract of the plant has also been used for millennia in India - Alexander the Great administered this plant to cure his general Ptolemy I Soter of a poisoned arrow. It was reported that Mahatma Gandhi took it as a tranquilizer during his lifetime. It has been used for millennia to treat insect stings and the bites of venomous reptiles. A compound which it contains called reserpine, was used in an attempt to treat high blood pressure and mental disorders including schizophrenia, and had a brief period of popularity for that purpose in the West from 1954 to 1957. *R. serpentina* is also known for its antimicrobial, antifungal, anti-inflammatory, antiproliferative, antidiuretic and anticholinergic activities.

Recent research has proved that *R. serpentina* exhibits profound activity toward drug-resistant tumour cells. It is one of the 50 fundamental herbs used in traditional Chinese medicine. Reserpine is an alkaloid first isolated from *R. serpentina* and was widely used as an antihypertensive drug. It had drastic psychological side effects and has been replaced as a first-line antihypertensive drug by other compounds that lack such adverse effects, although combination drugs that include it are still available in some countries as second-line antihypertensive drugs.

Other plants of this genus are also used medicinally, both in conventional western medicine and in Ayurveda, Unani, and folk medicine. Alkaloids in plants reduce blood pressure, depress activity of the central nervous system and act as hypnotics. *R. serpentina* is declining in the wild due to collection for its medicinal uses.

5.3.5-*Ephedra*

Ephedra is a medicinal preparation from the plant *Ephedra sinica*. Several additional species belonging to the genus *Ephedra* have traditionally been used for a variety of medicinal purposes, and are a possible candidate for the Soma plant of Indo-Iranian religion. It has been used in traditional Chinese medicine for more than 2,000 years. Native Americans and Mormon pioneers drank a tea brewed from other *Ephedra* species, called "Mormon tea" and "Indian tea". In recent years, ephedra-containing dietary supplements have been found to be unsafe, with reports of serious side effects and ephedra-related deaths.

Biochemistry and effects

A wide variety of alkaloid and non-alkaloid compounds have been identified in various species of *Ephedra*. Of the six ephedrine-type ingredients found in *Ephedra* (at concentrations of 0.02-3.4%), the most common are ephedrine and pseudoephedrine. The stimulant and thermogenic effects of *Ephedra sinica* and other *Ephedra* species are due to the presence of the alkaloids ephedrine and pseudoephedrine. These compounds stimulate the brain, increase heart rate, constrict blood vessels (increasing blood pressure), and expand bronchial tubes (making breathing easier). Their thermogenic properties cause an increase in metabolism, as evidenced by an increase in body heat.

Uses in sports

Ephedra is widely used by athletes as a performance-enhancing drug, despite a lack of evidence that it improves athletic performance. Ephedra may also be used as a precursor in the illicit manufacture of methamphetamine. Ephedra has been used as a weight-loss aid, sometimes in combination with aspirin and caffeine. However, several reports have documented a number of adverse events attributable to unregulated ephedra supplements. Adverse effects of ephedra consumption may include severe skin reactions, irritability, nervousness, dizziness, trembling, headache, insomnia, profuse perspiration, dehydration, itchy scalp and skin, vomiting, and hyperthermia. More serious potential side effects include irregular heartbeat, seizures, heart attack, stroke, and death.

Ephedrine is listed as a banned substance by both the International Olympic Committee and the World Anti-Doping Agency. Nonetheless, ephedra remains widely used by athletes; a 2006 survey of collegiate hockey players found that nearly half had used ephedra believing it enhanced their athletic performance.

In the 1994 FIFA World Cup, the Argentine footballer Diego Armando Maradona tested positive for ephedrine. The Japanese motorcycle racer Noriyuki Haga tested positive for ephedrine in 2000, being disqualified from two races and banned from two more as a result. NFL punter Todd Sauerbrun of the Denver Broncos was suspended for the first month of the 2006 season after testing positive for ephedrine.

5.4 WILD EDIBLE PLANTS (WEPS)

The term "wild edible plants" (WEPs) refers to species that are neither domesticated nor cultivated but still exist in the wild and are edible (Beluhan & Ranogajec, 2010). Throughout human history, several wild food plants have been important in all geographic regions. Poor populations all across the world depend on these wild plants for their food, nutrition, survival needs, and for enhancing rural livelihoods.

Forest is a common habitat for collection of these plants. There are many different types of wild food plants in Uttarakhand Himalaya. They are the source of food and nutrients to local community and could also be a source of income. If correctly documented, the selected plant species might be established as a crucial source of both money generating and dietary needs. Apart from the cultivated crop plant species, there are also a large number of wild plant species identified by local inhabitants, which provide them vegetables, fruits, seeds, nuts, roots, shoots, rhizomes, tubers, mushrooms, etc. round the year (Table 2). Wild edible plant species not only helpful in supporting the livelihood, but address the economic needs by selling them in the local market (Mehta, et al., 2010).

Significant work has been done by various workers on ethnobotany of wild edible plants in Himalayan region (Upreti et al., 2010and Upreti et al., 2017). The practice of consuming wild plants has not entirely disappeared, despite agricultural societies' predominance in relying on controlled varieties of plants and animals for subsistence. According to the FAO (2004) and Bharucha & Pretty (2010), millions of people, mainly in rural and tribal areas, continue to gather and consume a range of wild plant resources to meet their dietary needs. In general, wild food sources continue to be crucial for the poor and landless, and they become even more crucial in times of famine or conflict when normal food supply systems are disturbed and local or displaced populations have limited access to other types of food.

Ethnic community depends on nature and utilizes different plant species for food, medicine and various domestic needs. Wild edible plant species provide food security. Wild edibles can be easily grown without the use of pesticides and are less prone to illness. But, ironically other parts of the world still know little to nothing about these plants. The wild edible plant species could be popularized after phytochemical analysis and nutraceutical studies. The FAO be familiar with that nutrition and biodiversity converge towards a common goal of food safety and sustainable development and that wild species play a key role in global nutrition safety (FAO 2009). The nutritional potential of wild edible plants has not yet received the attention it merits in research.

5.4.1Role of WEPS

1. Wild edible plants (WEPs) play a significant role in family food baskets and are a staple of many traditional ethnic meals around the world.
2. WEPs still play an important role, when food crops are limited, they ensuring food security and sovereignty, as well as they may even improve the well-being of vulnerable households.
3. They maintain human and environmental health. Additionally, these plants are crucial in providing a balanced diet by supplementing basic foods with protein, fat, carbohydrates, trace elements, vitamins, and minerals. Due to their distinctive sensory appeal, socio-cultural and spiritual qualities, recreational value, and health benefits, they are often considered as famine foods noteworthy among aboriginal communities.

Table 2: Wild edible plant species used as fruits and vegetables by communities of Uttarakhand

S.N.	Plant Species	Local/Common Name	Family
A.	**Used as wild edible fruits**		
1	*Aegle marmelos* Linn.	Bail	Rutaceae
2	*Diploknema butyracea* (Roxb.) H. J.	Chura	Sapotaceae
3	*Bauhinia vahlii* Wight & Arn.	Malu	Fabaceae
4	*Cornus capitata* Wall. Syn. *Benthamidia capitata* Wallich ex Roxb. Hara	Bamaur	Cornaceae
5	*Berberis aristata* DC.	Chutar	Berberidaceae
6	*B. asiatica* Roxb ex DC	Kilmora	Berberidaceae
7	*Callicarpa macrophylla* Vahl.	Daya	Verbenaceae.
8	*Carissa opaca* Stapf ex Haines	Karaunj	Apocynaceae

9	*Castanea sativa* P. Mill.	Meetha pangar	Fagaceae
10	*Celtis australis* L.	Kharik	Ulmaceae
11	*Citrus medica* L.	Jamir	Rutaceae
12	*Corylces jacquemontii* Decne.	Bhotia badam / Kabasi	Betulaceae
13	*Debrigeasia longifolia* (Burm. F.) Wedd.	Tushar/Tushiyari	Urticaceae
14	*Diospyros melanoxylon* Roxb.	Taidua / Taidu	Ebenaceae
15	*Elaeagnus angustifolia* L.),	Giwai	Elaeagnaceae
16	*Ficus carica* L.	Anjir	Moraceae
17	*F. cunia* Buch.-Ham. ex Roxb.	*Dudila*	Moraceae
18	*F. glomerata* Roxb.	*Gular*	Moraceae
19	*F. palmata* Forsk.	*Bedu*	Moraceae
20	*F. semicordata* Buch.-Ham- ex J.E.)	*Khiriya*	Moraceae
21	*Fragaria indica* Andrews	Kaphai/Bhekaphal	Rosaceae
22	*Garuga pinnata* Roxb.	Titmar	Burseraceae
23	*Grewia optiva* J.R. Drummond ex. Burret	Bhimal	Malvaceae
24	*Hippophae tibetana* Schlecht.	Turuchuk	Elaeagnaceae
25	*Holboellia litifolia* var. *angustifolia* (Wallich) Hook. f. & Thomson	Gophal	Lardizabalaceae
26	*Juglans regia* L.	Akhrot	Juglandaceae
27	*Leea aspera* Edgew.	Kurmali	Vitaceae
28	*Madhuca indica* J.F. Gmelin	Mahua	Sapotaceae
29	*Morus serrata* Roxb.	Kimu	Moraceae
30	*Myrica esculenta* Buch.-Ham- ex D. Don	Kaphal	Myricaceae
31	*Phoenix humilis* Royle	Thankal	Arecaceae
32	*Phyllanthus emblica* L.	Aonla	Phyllanthaceae
33	*Pinus roxburghii* Sargent.	Chir	Pinaceae
34	*Prunus cerasoides* D. Don	Paya	Rosaceae
35	*Prunus cornuta* (Wallich ex Royle) Steudel	Jamun	Rosaceae
36	*Prunus napaulensis* Ser.	Bamhalu	Rosaceae
37	*Punica granatum* L.	Darim	Punicaceae
38	*Pyracantha crenulata* (D. Don) M. Roemer	Ghingaru	Rosaceae
39	*Pyrus lanata* Ham.	Mole	Rosaceae
40	*Pyrus pashia* Buch.-Ham. ex D. Don	Mehal	Rosaceae
41	*Rhododendron arboreum* Smith	Buransh	Ericaceae
42	*Ribes alpestre* var. *giganteum* Wallich ex)	Sirkuti	Grossulariaceae
43	*Tamarindus indica* L.	Imali	Fabaceae

44	*Rosa macrophylla* Lindley	Phelalo	Rosaceae
45	*R. sericea* Lindley	Sepala	Rosaceae
46	*Rubus niveus* (Hook f.) Kuntze	Kala hisalu	Rosaceae
47	*Rubus ellipticus* Smith	Hisalu	Rosaceae
48	*Schliechera oleosa* (Lour.) Oken	Kusum	Sapindaceae
49	*Solanum nigrum* L.	Makoi/Makhou	Solanaceae
50	*Solena amplexicaulis* (Lam.) Gandhi	Mat kakari	Cucurbitaceae
51	*Sorbus cuspidate* (Spach) Hedlund	Nepalo/Nepala	Rosaceae
52	*Spondias pinnata* (L.F.) Kurz	Aam/Aami	Anacardiaceae
53	*Taxillus vestita* (Wallich) Danser	Bani/Ban	Loranthaceae
54	*Tulipa stellata* Hook.	Mijhau	Liliaceae
55	*Viburnum cotinifolium* D. Don	Ghatmila	Viburnaceae
56	*Viburnum mullah* Buch.-Ham. ex D. Don	Titmalewa	Viburnaceae
57	*Vitis lanata* Roxb.	Purain	Vitaceae
58	*Ziziphus mauritiana* Lam.	Beri	Rhamnaceae
B	**Used as wild edible vegetables**		
1	*Agave americana* L.	Rambans	Asparagaceae
2	*Angelica glauca* Edgew	Hanw	Apiaceae
3	*Arisaema speciosum* Wallich C. martius	Bankh	Araceae
4	*Asparagus filicinus* Buch.-Ham. ex Roxb.	Kairua	Asparagaceae
5	*Bauhinia variegata* L.	Kwairal	Fabaceae
6	*Berberis asiatica* DC.	Kilmora	Berberidaceae
7	*Ceiba pentendra* L.	Semal	Malvaceae
8	*Chaerophyllum villosum* Wall. ex DC.	Ganziadi	Apiaceae
9	*Chenopodium album* L.	Bathua	Amaranthaceae
10	*Colocasia esculenta* (L.) Schott	Gadpapar	Araceae
11	*Dioscora bulbifera* L.	Genthi	Dioscoreaceae
12	*Dioscorea glabra* Roxb.	Tarur	Dioscoreaceae
13	*Diplazium esculentum* Retz.	Lingura	Athyriaceae
14	*Fagophyrum cymosum* Trevirances meisn	Jhangar	Polygonaceae
15	*Ficus auriculata* Lour	Timila/Timul	Moraceae
16	*Ficus palmata* Forsk	Bedu	Moraceae
17	*Indigofera pulchella* Roxb.	Sakina	Fabaceae
18	*Lepidium sativum* L.	Halang	Brassicaceae
19	*Morchella esculenta* (L.) Pers.	Mushroom/Bhangbho	Morchellaceae

20	*Moringa oleifera* Lam.	Sonjal	Moringaceae
21	*Nasturtium officinale* R. Br.	Machhai/Padya	Brassicaceae
22	*Phytolacca acinosa* Roxb.	Jarag	Phytolaccaceae
23	*Polystichium acullalum* (L.) Roth.	Quathode	Dryopteridaceae
24	*Puerarea tuberosa* Roxb. ex Willd. DC.	Birau/Bilikand	Fabaceae
25	*Rhododendron arboreum* Smith	Burash	Ericaceae
26	*Typhonium diversifolium* Wallich ex Schott	Rugi	Araceae
27	*Urtica ardens* Link.	Bichchhu ghas	Urticaceae

5.5 OIL-YIELDING PLANTS

5.5.1-Castor

Castor (*Ricinus communis*), the castor oil plant, is a species of flowering plant belonging to the family Euphorbiaceae. *R.communis* is the sole species in the monotypic genus, *Ricinus*, and subtribe, Ricininae. The evolution of castor and its relation to other species are currently being studied using modern genetic tools. Although *R. communis* is indigenous to the southeastern Mediterranean Basin, Eastern Africa, and India, today it is widespread throughout tropical regions. In areas with a suitable climate, castor establishes itself easily where it can become an invasive plant and can often be found on wasteland.

Biology

R. communis can vary greatly in its growth habit and appearance. The variability has been increased by breeders who have selected a range of cultivars for leaf and flower colours, and for oil production. It is a fast-growing, suckering perennial shrub that can reach the size of a small tree (around 12 m), but it is not cold hardy.

Uses

Castor seed is the source of castor oil, which has a wide variety of uses. The seeds contain between 40% and 60% oil that is rich in triglycerides, mainly ricinolein. The seed also contains ricin, a water-soluble toxin, which is also present in lower concentrations throughout the plant.

Castor oil has many uses in medicine and other applications. An alcoholic extract of the leaf was shown, in lab rats, to protect the liver from damage from certain poisons. Methanolic extracts of the leaves of *R. communis* were used in antimicrobial testing against eight pathogenic bacteria in rats and showed antimicrobial properties. A water extract of the root bark showed analgesic activity in rats. Antihistamine and anti-inflammatory properties were found in ethanolic extract of *Ricinus communis* root bark. Extract of *R. communis* exhibited acaricidal and insecticidal activities against the adult of *Haemaphysalis bispinosa* Neumann (Acarina: Ixodidae) and hematophagous fly *Hippobosca maculata* Leach (Diptera: Hippoboscidae). The Bodo tribals of Bodoland, Assam (India) use the leaves of this plant to feed and rear the larvae of muga and endi silkworms.

Castor oil is an effective motor lubricant and has been used in internal combustion engines, including those of World War I airplanes, some racing cars and some model airplanes. It has historically been popular for lubricating two-stroke engines due to high resistance to heat compared to petroleum-based oils. In Brazil, castor oil (locally known as mamona oil) is now being used to produce biodiesel. In rural areas, the abundant seeds are used by children for slingshot balls, as they have the right weight, size, and hardness.

Castor oil was traditionally used on the skin to prevent dryness. This is now used as a base for many cosmetics. Castor oil in a processed form, called Polyglycerol polyricinoleate—or PGPR, is currently being used in chocolate bar manufacturing as a less expensive substitute for cocoa butter. Selections have been made by breeders for use as ornamental plants and for commercial production of castor oil. Commercially available cold-pressed castor oil is not toxic to humans in normal doses, either internal or externally.

5.5.2-Coconut

Coconut tree (*Cocos nucifera*) is a plant that belongs to the family Arecaceae. The term coconut can refer to the entire coconut palm, the seed, or the fruit, which, botanically, is a drupe, not a nut. There are over 150 species of coconuts that can be found in 80 different countries throughout the world. Coconut tree grows only in the tropical climate. This plant live on the sandy soil, requires a lot of sunlight and regular rainfalls. Coconut tree does not tolerate low temperatures and low percent of humidity. Cultivated plants are prone to insect attacks which can decrease production of fruit worth of hundreds of million dollars.

The origin, domestication, cultivation, production, religious importance and its uses as coir have been described in Unit 2. The culinary uses and nutritional value are being described here.

Culinary uses and nutritional value

The various parts of the coconut have a number of culinary uses. The seed provides oil for frying, cooking, and making margarine. The white, fleshy part of the seed, the coconut meat, is used fresh or dried in cooking, especially in confections and desserts such as macaroons. Desiccated coconut or coconut milk made from it is frequently added to curries and other savory dishes. Coconut flour has also been developed for use in baking, to combat malnutrition. Coconut chips have been sold in the tourist regions of Hawaii and the Caribbean. Coconut butter is often used to describe solidified coconut oil, but has also been adopted as a name by certain specialty products made of coconut milk solids or puréed coconut meat and oil. Dried coconut is also used as the filling for many chocolate bars. Some dried coconut is purely coconut but others are manufactured with other ingredients, such as sugar, propylene glycol, salt, and sodium metabisulfite.

Per 100 gram serving with 354 calories, raw coconut meat supplies a high amount of total fat (33 grams), especially saturated fat (89% of total fat) and carbohydrates (24 grams). Micronutrients in significant content include the dietary minerals, manganese, iron, phosphorus and zinc.

Coconut water serves as a suspension for the endosperm of the coconut during its nuclear phase of development. Later, the endosperm matures and deposits onto the coconut rind during the cellular phase. It is consumed throughout the humid tropics, and has been introduced into the retail market as a processed sports drink. Mature fruits have significantly less liquid than young, immature coconuts, barring spoilage. Coconut water can be fermented to produce coconut vinegar. Per 100 gram (100 ml) serving, coconut water contains 19 calories and no significant content of essential nutrients.

Coconut milk, not to be confused with coconut water, is obtained primarily by extracting juice by pressing the grated coconut white kernel or by passing hot water or milk through grated coconut, which extracts the oil and aromatic compounds. It has a fat content of around 23%. When refrigerated and left to set, coconut cream will rise to the top and separate from the milk. The milk can be used to produce virgin coconut oil by controlled heating and removal of the oil fraction. A protein-rich powder can be processed from coconut milk following centrifugation, separation and spray drying.

Another byproduct of the coconut is coconut oil. It is commonly used in cooking, especially for frying. It can be used in liquid form as would other vegetable oils, or in solid form as would butter or lard.

In southern India, most common way of cooking vegetables is to add grated coconut and then steam them with spices fried in oil. People from southern India also make chutney, which involves grinding the coconut with salt, chillies, and whole spices. Coconut ground with spices is also mixed in *sambar* and other various lunch dishes for extra taste. Coconut meat can be eaten as a snack sweetened with jaggery or molasses. In Karnataka sweets are prepared using coconut and dry coconut "copra".

5.5.3-Linseed

Flax (also known as linseed), with the binomial name *Linum usitatissimum*, is a member of the genus *Linum* in the family Linaceae. It is a food and fibre crop that is grown in cooler regions of the world. The textiles made from flax are known in the West as linen, and traditionally used for bed sheets, underclothes and table linen. The oil is known as linseed oil. In addition to referring to the plant itself, the word "flax" may refer to the unspun fibres of the flax plant. The plant species is known only as a cultivated plant, and appears to have been domesticated just once from the wild species *L. bienne*, called pale flax.

Several other species in the genus *Linum* are similar in appearance to *L. usitatissimum*, cultivated flax, including some that have similar blue flowers and others with white, yellow, or red flowers. Some of these are perennial plants, unlike *L. usitatissimum*, which is an annual plant.

Origin and domestication

Flax was first domesticated in the Fertile Crescent region. Use of the crop steadily spread, reaching places as far as Switzerland and Germany by 5,000 years ago (3,000 BC). In China and India domesticated flax was cultivated by at least 5,000 years ago (3,000 BC).

History

Flax was extensively cultivated in ancient Egypt, where temple walls had paintings of flowering flax and mummies were entombed in linen. Egyptian priests only wore linen, as flax was considered a symbol of purity. Phoenicians traded Egyptian linen throughout the Mediterranean, and the Romans used it for their sails. As the Roman Empire declined, so did flax production, but Charlemagne revived the crop in the 8th century CE with laws designed to publicize the hygiene of linen textiles and the health of linseed oil. Eventually, Flanders became the major centre of the linen industry in the European Middle Ages. In North America, flax was introduced by the colonists and it flourished there. But by the early 20th century cheap cotton and rising farm wages had caused production of flax to become concentrated in northern Russia, which came to provide 90% of the world's output. Since then flax has lost its importance as a commercial crop, due to the easy availability of more durable fibres.

Uses

Flax is grown for its oil, used as a nutritional supplement, and as an ingredient in many wood-finishing products. Flax is also grown as an ornamental plant in gardens. Flax fibres are used to make linen. The Latin species name *usitatissimum* means *most useful*.

Flax fibres are taken from the stem of the plant and are two to three times as strong as those of cotton. As well, flax fibres are naturally smooth and straight. Europe and North America depended on flax for vegetable-based cloth until the nineteenth century, when cotton overtook flax as the most common plant used for making rag-based paper. Flax is grown on the Canadian Prairies for linseed oil, which is used as a drying oil in paints and varnish and in products such as linoleum and printing inks.

Nutritional value

Flax seeds come in two basic varieties: 1. brown; and 2. yellow or golden (also known as golden linseeds). Most types have similar nutritional characteristics and equal numbers of short-chain omega-3 fatty acids. The exception is a type of yellow flax called solin (trade name Linola), which has a completely different oil profile and is very low in omega-3 FAs. Flax seeds produce a vegetable oil known as flax seed oil or linseed oil, which is one of the oldest commercial oils. It is an edible oil obtained by expeller pressing, sometimes followed by solvent extraction. Solvent-processed flax seed oil has been used for many centuries as a drying oil in painting and varnishing. Although brown flax can be consumed as readily as yellow, and has been for thousands of years, its better-known uses are in paints, for fibre, and for cattle feed.

In a 100 gram serving, flax seeds supply 534 calories and contain high levels (> 19% of the Daily Value, DV) of protein, dietary fibre, several B vitamins and dietary minerals . Flax seeds are especially rich in thiamin, magnesium and phosphorus (DVs above 90%).

As a percentage of total fat, flaxseeds contain 54% omega-3 fatty acids (mostly ALA), 18% omega-9 fatty acids (oleic acid) and 6% omega-6 fatty acids (linoleic acid); the seeds contain 9% saturated fat, including 5% as palmitic acid. Flaxseed oil contains 53% 18:3 omega-3 fatty acids (mostly ALA) and 13% 18:2 omega-6 fatty acids.

L. usitatissimum seeds have been used in the traditional Austrian medicine internally (directly soaked or as tea) and externally (as compresses or oil extracts) for treatment of disorders of the respiratory tract, eyes, infections, cold, flu, fever, rheumatism and gout.

Production

The largest producer of flax is Canada followed by China, Russia and India, among top 10 others. Flax is harvested for fibre production after approximately 100 days or a month after the plant flowers and two weeks after the seed capsules form. The base of the plant will begin to turn yellow. If the plant is still green, the seed will not be useful, and the fibre will be underdeveloped. The fibre degrades once the plant is brown.

Harvesting

Flax grown for seed is allowed to mature until the seed capsules are yellow and just starting to split; it is then harvested in various ways. A combine harvester may either cut only the heads of the plants, or the whole plant. These are then dried to extract the seed. The amount of weeds in the straw affects its marketability, and this coupled with market prices determines whether the farmer chooses to harvest the flax straw. If the flax straw is not harvested, it is typically burned, since the stalks are quite tough and decompose slowly (*i.e.*, not in a single season). Still being somewhat in a windrow from the harvesting process, the straw would often clog up tillage and planting equipment. Flax straw that is not of sufficient quality for fibre uses can be baled to build shelters for farm animals, or sold as bio-fuel, or removed from the field in the spring. There are two ways to harvest flax fibre, one involving mechanized equipment (combines), and a second method, more manual and targeted towards maximizing the fibre length.

5.5.4-Groundnut

The peanut or groundnut (*Arachis hypogaea*) is a species in the family Fabaceae. The peanut was probably first domesticated and cultivated in the valleys of Paraguay. It is an annual herbaceous plant growing 30 to 50 cm tall. The flowers are a typical pea flower in shape, 2 to 4 cm across, yellow with reddish veining. The specific name, *hypogaea* means "under the earth"; after pollination, the flower stalk elongates, causing it to bend until the ovary touches the ground. Continued stalk growth then pushes the ovary underground where the mature fruit develops into a legume pod, the peanut - a classical example of geocarpy. Pods are 3 to 7 cm long, normally containing 1 to 4 seeds. Because, in botanical terms, "nut" specifically refers to indehiscent fruit, the peanut is not technically a nut, but rather a legume.

Origin and domestication

The domesticated peanut is an amphidiploid or allotetraploid, meaning that it has two sets of chromosomes from two different species, thought to be *A. duranensis* and *A. ipaensis*. These probably combined in the wild to form the tetraploid species *A. monticola*, which gave rise to the domesticated peanut. This domestication might have taken place in Paraguay or Bolivia, where the wildest strains grow today. Many pre-Columbian cultures, such as the Moche, depicted peanuts in their art. Archaeologists have dated the oldest specimens to about 7,600 years, found in Peru. Although the peanut was mainly a garden crop for much of the colonial period of North America, it was mostly used as animal feed stock until the 1930s.

Production

China leads in production of peanuts, having a share of about 42% of overall world production, followed by India (12%) and the United States of America (8%). Thousands of peanut cultivars are grown, with four major cultivar groups being the most popular: Spanish, Runner, Virginia, and Valencia. There are also Tennessee red and white groups. Certain cultivar groups are preferred for particular uses because of differences in flavour, oil content, size, shape, and disease resistance. For many uses, the different cultivars are interchangeable. Most peanuts marketed in the shell are of the Virginia type, along with some Valencias selected for large size and the attractive appearance of the shell. Spanish peanuts are used mostly for peanut candy, salted nuts, and peanut butter. Most Runners are used to make peanut butter. The various types are distinguished by branching habit and branch length. There are numerous varieties of each type of peanut. There are two main growth forms, bunch and runner. Bunch types grow upright, while runner types grow near the ground. Each year, new cultivars of peanuts are bred and introduced.

Uses

Peanuts can be eaten raw, used in recipes, made into oils, textile materials, and peanut butter, as well as many other uses. In general, peanut products are considered safe for human use, although there are insufficient studies about peanut aflatoxins and uses for cosmetics. Popular confections made from peanuts include salted peanuts, peanut butter (sandwiches, peanut candy bars, peanut butter cookies, and cups), peanut brittle, and shelled nuts (plain/roasted). Salted peanuts are usually roasted in oil and packed in retail-size plastic bags or hermetically sealed cans.

Peanuts are used to help fight malnutrition. Peanuts can be used like other legumes and grains to make a lactose-free milk-like beverage, peanut milk. Peanut milk is promoted in Africa as a way to reduce malnutrition among children. Low-grade or culled peanuts not suitable for the edible market are used in the production of peanut oil for manufacturing. The protein cake (oilcake meal) residue from oil processing is used as an animal feed and as a soil fertilizer. Raw peanuts are also widely sold as a garden bird feed. Peanuts also have a variety of industrial end uses. Paint, varnish, lubricating oil, leather dressings, furniture polish, insecticides, and nitroglycerine are made from peanut oil. Soap is made from saponified oil, and many cosmetics contain peanut oil and its derivatives. The protein portion is used in the manufacture of some textile fibres. Peanut shells are used in the manufacture of plastic, wallboard, abrasives, fuel, cellulose (used in rayon and paper) and mucilage (glue). Rudolf Diesel ran some of the first engines that bear his name on peanut oil and it is still seen as a potentially useful fuel.

Nutritional value

Peanuts are rich in essential nutrients. In a 100 g serving, peanuts provide 570 calories and are an excellent source (defined as more than 20% of the Daily Value, DV) of several B vitamins, vitamin E, several dietary minerals, such as manganese (95% DV), magnesium (52% DV) and phosphorus (48% DV), and dietary fibre. They also contain about 25 g protein per 100 g serving, a higher proportion than in many tree nuts.

Recent research on peanuts has found polyphenols and other phytochemicals that are under basic research for their potential to provide health benefits. New research shows peanuts, especially the skins, to have comparable polyphenol content of many fruits. Peanut skins are a significant source of resveratrol, a phenolic under research for a variety of potential effects in humans.

A common cooking and salad oil, peanut oil is 46% monounsaturated fats (primarily oleic acid), 32% polyunsaturated fats (primarily linoleic acid) and 17% saturated fats (primarily palmitic acid). Extractable from whole peanuts using a simple water and centrifugation method, the oil is being considered by NASA's Advanced Life Support program for future long-duration human space missions.

Peanuts may be contaminated with the mold *Aspergillus flavus* which produces a carcinogenic substance called aflatoxin. Lower quality specimens, particularly where mold is evident, are more likely to be contaminated.

International trade

Although India and China are the world's largest producers of peanuts, they account for a small part of international trade because most of their production is consumed domestically as peanut oil. Exports of peanuts from India and China are equivalent to less than 4% of world trade. The major producers/exporters of peanuts are the United States, Argentina, Sudan, Senegal, and Brazil. These five countries account for 71% of total world exports. In recent years, the United States has been the leading exporter of peanuts. The major peanut importers are the European Union (EU), Canada, and Japan. These three areas account for 78% of the world's imports.

5.5.5-Mustard

Mustard and rapeseed (canola) is the third largest vegetable oil traded in the world, next to soybean and palm oil. A genetically modified variety of rapeseed (*Brassica spp.)* that was developed by Canadian plant breeders specifically for its nutritional qualities and its low level of saturated fat is known as Canola, which is a short form of "Canadian oil".

Description

Brassica species are cultivated since historic times, particularly in Asian countries. According to ancient Indian literature, cultivation of *Brassica rapa* was practiced since 1500 BC and seed of *Brassica juncea* (Indian mustard) was reported to have found in archaeological sites. On the other hand, the Chinese word for rapeseed was first recorded 2500 years ago, and the oldest archaeological discoveries reported to be dated back to 5000 BC.

Rapeseed oil reported to be used as a marine and industrial lubricant during World War II and consequently, the market for rapeseed oil plummeted in the post war period. Production of rapeseed has been rising rather steeply during the past two decades and has outpaced the production of other oilseeds including peanut, cottonseed and sunflower.

Seed: Rapeseed and mustard is grown for its oil rich seeds. Apart from extracting oil, seeds are also used directly in the preparation of almost all Indian curries particularly in a process called "tadka"
Oil: Well-developed rapeseed seed contains 40 to 44% of edible oil.
Meal: Seed extract after recovering oil is used as a feed.
Recovery on average: Oil to Seeds– 33%; Cake to Seeds– 67%

Cultivation

Rapeseed and mustard can be cultivated in both tropical as well as temperate climates. Its growth is most vigorous in temperatures between 10°C and 30°C with an optimum temperature of around 20°C. Seed oil formation is optimum at a temperature of 10°C to 15°C. The crop is very sensitive to high temperatures as well as for frost at the time of flowering. Crop growth is healthy at a rainfall of 350-550 mm.

Rapeseed and mustard are normally cultivated as a rabi crop in India as it requires relatively cooler temperatures for seed setting and oil formation. Sowing normally starts in the month of November and the crop season spreads up to April.

Production

World output of rapeseed and mustard has been increasing persistently and rather steeply during the past 15 years. The output has doubled from about 36 million tonnes in 2001-02 to 70 million tonnes in 2013-14. Production from European Union and Canada has risen steadily and reached to nearly 30% and 26% respectively of total world production. On the other hand, output from China has remained largely stable at around 12-13 million tonnes and consequently its share has declined to about 20% from about 31% a decade ago.

The steep rise in production from Canada was primarily on account of significant expansion in area, which could have apparently been driven by a sharp rise in exports from Canada. While the production and consumption doubled during the past decade, trade has gone up by three times. During this period, exports from Canada rose by nearly four times.

Similar to production, world consumption pattern of rapeseed and mustard also doubled during the past 15 years primarily driven by the European Union, China and Canada. The European Union registered growth followed by Canada and China. Consequently, imports by China and the EU rose the steepest pushing them to top two positions replacing Japan and Mexico.

India is the fourth largest producer of rapeseed & mustard. Production trends over the past two decades indicated that there was a significant shift in production levels from about 5-6 million tonnes until 2002-03 to around 7-8 million tonnes during the past one decade. The jump in production was primarily on account of sharp rise in yields. In addition, there was a significant expansion in area under rapeseed during the same period.

Rajasthan occupies the first place both in terms of cultivated area and production accounting for over 45% followed by Madhya Pradesh with 13%. Haryana and Uttar Pradesh occupy the third place contributing for 11% of total production each. Thus, the top four states produce about 80% of total rapeseed & mustard production in the country.

5.6 BEVERAGES

5.6.1-Tea

Tea is an aromatic beverage commonly prepared by pouring hot or boiling water over cured leaves of the *Camellia sinensis*, an evergreen shrub native to Asia. After water, it is the most widely consumed drink in the world. Some teas, like Darjeeling and Chinese greens, have a cooling, slightly bitter, and astringent flavour, while others have vastly different profiles that include sweet, nutty, floral, or grassy notes.

Origin and history

Tea originated in China, possibly as a medicinal drink. It came to the West via Portuguese priests and merchants, who introduced it during the 16th century. Drinking tea became fashionable among Britons during the 17th century, who started large scale production and commercialization of the plant in India to bypass a Chinese monopoly at that time.

Tea plants are native to East Asia, and probably originated around the meeting points of the lands of northern Burma (Myanmar) and south-western China. Chinese legends attribute the invention of tea to Shennong in 2737 BC. A Chinese inventor was the first person to invent a tea shredder. The first recorded drinking of tea is in China, with the earliest records of tea consumption dating to the 10th century BC. In India, it has been drunk for medicinal purposes for a long but uncertain period, but apart from the Himalayan region seems not to have been used as a beverage until the British introduced Chinese tea there.

The first European to successfully transplant tea to the Himalayas, Robert Fortune, was sent by the East India Company on a mission to China in 1848 to bring the tea plant back to Great Britain. He began his journey in high secrecy as his mission occurred in the lull between the Anglo-Chinese First Opium War (1839–1842) and Second Opium War (1856–1860), at a time when westerners were not held in high regard.

Tea was introduced into India by the British. The British brought Chinese seeds into North-eastern India, but the plants failed; they later discovered that a different variety of tea was endemic to Assam and the northeastern region of India and that it was used by a local tribe Siphung. Using the Chinese planting and cultivation techniques, the British launched a tea industry by offering land in Assam to any European who agreed to cultivate it for export. Tea was originally consumed only by anglicized Indians; it became widely popular in India in the 1950s because of a successful advertising campaign by the India Tea Board.

Cultivation

C. sinensis is an evergreen plant that grows mainly in tropical and subtropical climates. Some varieties can also tolerate marine climates and are cultivated as far north as Cornwall in the United Kingdom, Perthshire in Scotland, Washington state in the United States and Vancouver Island in Canada. In the Southern Hemisphere, tea is grown as far south as Hobart on the Australian island of Tasmania and Waikato in New Zealand.

Tea plants are propagated from seed and cuttings; about 4 to 12 years are needed for a plant to bear seed and about three years before a new plant is ready for harvesting. In addition to a zone 8 climate or warmer, tea plants require at least 127 cm of rainfall a year and prefer acidic soils.

Many high-quality tea plants are cultivated at elevations of up to 1,500 m above sea level. While at these heights the plants grow more slowly, they acquire a better flavour.

Two principal varieties are used: *C. sinensis* var. *sinensis*, which is used for most Chinese, Formosan and Japanese teas, and *C. s.* var. *assamica*, used in most Indian teas (but not Darjeeling). Within these botanical varieties, many strains and modern clonal varieties are known. Leaf size is the chief criterion for the classification of tea plants, with three primary classifications being, Assam type, characterised by the largest leaves; China type, characterised by the smallest leaves; and Cambodian type, characterised by leaves of intermediate size.

A tea plant will grow into a tree of up to 16 m if left undisturbed, but cultivated plants are generally pruned to waist height for ease of plucking. Also, the short plants bear more new shoots which provide new and tender leaves and increase the quality of the tea. Only the top 1–2 inch of the mature plant are picked. These buds and leaves are called 'flushes'. A plant will grow a new flush every seven to 15 days during the growing season. Leaves that are slow in development tend to produce better-flavoured teas.

Types of tea

Tea is generally divided into categories based on how it is processed. At least six different types are produced: White- Wilted and unoxidized; Yellow-Unwilted and unoxidized, but allowed to yellow; Green-Unwilted and unoxidized; Oolong-Wilted, bruised, and partially oxidized; Black: Wilted, sometimes crushed, and fully oxidized (called 'red tea' in China), and Post-Fermented: Green tea that has been allowed to ferment/compost ('black tea' for the Chinese). The most common are white, green, oolong, and black.

Processing

After picking, the leaves of *C. sinensis* soon begin to wilt and oxidize unless immediately dried. An enzymatic oxidation process triggered by the plant's intracellular enzymes causes the leaves to turn progressively darker as their chlorophyll breaks down and tannins are released. This darkening is stopped at a predetermined stage by heating, which deactivates the enzymes responsible. In the production of black teas, halting by heating is carried out simultaneously with drying.

Although single-estate teas are available, almost all tea in bags and most loose tea sold in the West are blended. Such teas may combine others from the same cultivation area or several different ones. The aim is to obtain consistency, better taste, higher price, or some combination of the three.

Tea easily retains odours, which can cause problems in processing, transportation, and storage. This same sensitivity also allows for special processing (such as tea infused with smoke during drying) and a wide range of scented and flavoured variants, such as bergamot (found in Earl Grey), vanilla, and spearmint.

Nutrients and phytochemicals

Caffeine constitutes about 3% of tea's dry weight, translating to between 30 mg and 90 mg per 250 ml cup depending on type, brand, and brewing method. A study found that the caffeine content of 1 g of black tea ranged from 22 to 28 mg, while the caffeine content of 1 g of green tea ranged from 11 to 20 mg, reflecting a significant difference. Tea also contains small amounts of theobromine and theophylline, which are stimulants and xanthines similar to caffeine.

Tea leaves contain diverse polyphenols, including flavonoids, epigallocatechin gallate (commonly noted as EGCG) and other catechins. It has been suggested that green and black tea may protect against cancer or other diseases such as obesity or Alzheimer's disease, but the compounds found in green tea have not been conclusively demonstrated to have any effect on human diseases. One human study demonstrated that regular consumption of black tea over four weeks had no beneficial effect in lowering blood cholesterol levels.

Tea culture

Tea may be consumed early in the day to heighten calm alertness; it contains L-theanine, theophylline, and bound caffeine (sometimes called *theine*). Decaffeinated brands are also sold. While herbal teas are also referred to as tea, most of them do not contain leaves from the tea plant. While tea is the second most consumed beverage on Earth after water, in many cultures it is also consumed at elevated social events, such as afternoon tea and the tea party.

In India, tea is one of the most popular hot beverages. It is consumed daily in almost all homes, offered to guests, consumed in high amounts in domestic and official surroundings, and is made with the addition of milk with or without spices. In the United States, 80% of tea is consumed as iced tea. Switzerland has its own unique blend of iced tea. In the United Kingdom, it is consumed daily and often by a majority of people across the country, and indeed is perceived as one of Britain's cultural beverages.

Popular varieties of black tea include Assam, Iran, Nepal, Darjeeling, Nilgiri, Turkish, Keemun, and Ceylon teas. In India, black tea is often boiled for fifteen minutes or longer to make Masala chai, as a strong brew is preferred. Tea should be strained while serving.

In regions of the world that prefer mild beverages, such as the West and Far East, green tea should be steeped in water around 80 to 85 °C, the higher the quality of the leaves the lower the temperature. Regions such as North Africa or Central Asia prefer a bitter tea, and hotter water is used. In Morocco, green tea is steeped in boiling water for 15 minutes. High-quality green and white teas can have new water added as many as five or more times, depending on variety, at increasingly higher temperatures.

Flowering tea or blooming tea should be brewed at 100 °C in clear glass tea wares for up to three minutes.

Tea is the most popular manufactured drink consumed in the world, equalling all others – including coffee, chocolate, soft drinks, and alcohol – combined. Most tea consumed outside East Asia is produced on large plantations in the hilly regions of India and Sri Lanka, and is destined to be sold to large businesses. India is the world's largest tea-drinking nation although the per capita consumption of tea remains a modest 750 grams per person every year. Turkey, with 2.5 kg of tea consumed per person per year, is the world's greatest per capita consumer.

Production

In 2003, world tea production was 3.21 million tonnes annually. In 2010, world tea production reached over 4.52 million tonnes after having increased by 5.7% between 2009 and 2010. Production rose by 3.1% between 2010 and 2011. The largest producers of tea are the People's Republic of China, India, Kenya, Sri Lanka, and Turkey.

International trade

According to the FAO in 2007, the largest importer of tea, by weight, was the Russian Federation, followed by the United Kingdom, Pakistan, and the United States. Kenya, China, India and Sri Lanka were the largest exporters of tea in 2007. The largest exporter of black tea is Kenya, largest producer (and consumer) India.

5.6.2-Coffee

All coffee plants belong to family Rubiaceae. Several species of the genus *Coffea* produce the berries from which coffee is extracted. The two main species commercially cultivated are *C. canephora* (predominantly a form known as 'robusta') and *C. arabica*. *C. arabica*, the most highly regarded species, is native to the southwestern highlands of Ethiopia and the Boma Plateau in southeastern Sudan and possibly Mount Marsabit in northern Kenya. *C. canephora* is native to western and central Subsaharan Africa, from Guinea to the Uganda and southern Sudan. Less popular species are *C. liberica*, *C. stenophylla*, *C. mauritiana,* and *C. racemosa*.

Biology

Coffee are evergreen shrubs or trees that may grow 5 m tall when unpruned. The flowers are followed by oval berries of about 1.5 cm. When immature they are green, and they ripen to yellow, then crimson, before turning black on drying. Each berry usually contains two seeds, but 5–10% of the berries have only one; these are called peaberries. *Arabica* berries ripen in six to eight months, while *robusta* take nine to eleven months.

C. arabica is predominantly self-pollinating, and as a result the seedlings are generally uniform and vary little from their parents. In contrast, *C. canephora*, and *C. liberica* are self-incompatible and require outcrossing. This means that useful forms and hybrids must be propagated vegetatively. Cuttings, grafting, and budding are the usual methods of vegetative propagation. On the other hand, there is great scope for experimentation in search of potential new strains.

Cultivation

Coffee is a brewed drink prepared from roasted coffee beans, which are the seeds of "berries" from the *Coffea* plant. Coffee plants are cultivated in over 70 countries, primarily in the equatorial regions of the Americas, Southeast Asia, India and Africa. The two most commonly grown are the highly regarded *arabica*, and the less sophisticated but stronger and more hardy *robusta*. The latter is resistant to the coffee leaf rust, *Hemileia vastatrix*, but has a more bitter taste. Once ripe, coffee beans are picked, processed, and dried. Green (unroasted) coffee beans are one of the most traded agricultural commodities in the world. Once traded, the beans are roasted to varying degrees, depending on the desired flavour, before being ground and brewed to create coffee.

Uses

Coffee is slightly acidic (pH 5.0–5.1) and can have a stimulating effect on humans because of its caffeine content. Coffee is one of the most popular drinks in the world. It can be prepared and presented in a variety of ways (e.g., espresso, cappucino, cafe latte, etc.). It is usually served hot, although iced coffee is also served. The effect of coffee on human health has been a subject of many studies; however, results have varied in terms of coffee's relative benefit. The majority of recent research suggests that moderate coffee consumption is benign or mildly beneficial in healthy adults. However, the diterpenes in coffee may increase the risk of heart disease.

Coffee cultivation first took place in Southern Arabia. The earliest credible evidence of coffee-drinking appears in the middle of the 15^{th} century in the Sufi shrines of Yemen. Coffee is a major export commodity. It has become a vital cash crop for many developing countries. Over one hundred million people in developing countries have become dependent on coffee as their primary source of income. It has become the primary export and backbone for African countries like Uganda, Burundi, Rwanda, and Ethiopia, as well as many Central American countries. Further, green (unroasted) coffee is one of the most traded agricultural commodities in the world.

About three-quarters of coffee cultivated worldwide is *C. arabica*. *Robusta* coffee is used as an inexpensive substitute for *arabica* in many commercial coffee blends. Good quality *robusta* beans are used in traditional Italian espresso blends to provide a full-bodied taste and a better foam head (known as *crema*). However, *C. canephora* is less susceptible to disease than *C. arabica* and can be cultivated in lower altitudes and warmer climates where *C. arabica* will not thrive. The spread of the devastating coffee leaf rust (*H. vastatrix*), to which *C. arabica* is vulnerable, hastened the uptake of the resistant *robusta*. Coffee leaf rust is found in virtually all countries that produce coffee.

Production
In 2011 Brazil was the world leader in production of green coffee, followed by Vietnam, Indonesia and Colombia. Arabica coffee seeds are cultivated in Latin America, eastern Africa, Arabia, or Asia. Robusta coffee seeds are grown in western and central Africa, throughout Southeast Asia, and to some extent in Brazil.

Seeds from different countries or regions can usually be distinguished by differences in flavour, aroma, body, and acidity. These taste characteristics are dependent not only on the coffee's growing region, but also on genetic subspecies (varietals) and processing. Varietals are generally known by the region in which they are grown, such as Colombian, Java and Kona.

Processing
Coffee berries and their seeds undergo several processes before they become the familiar roasted coffee. Berries have been traditionally selectively picked by hand; a labour-intensive method, it involves the selection of only the berries at the peak of ripeness. More commonly, crops are strip picked, where all berries are harvested simultaneously regardless of ripeness by person or machine. After picking, green coffee is processed by one of two methods-the dry process method, simpler and less labour-intensive as the berries can be strip picked, and the wet process method, which incorporates fermentation into the process and yields a mild coffee.

A number of products are sold for the convenience of consumers who do not want to prepare their own coffee. Instant coffee is dried into soluble powder or freeze-dried into granules that can be quickly dissolved in hot water. Originally invented in 1907, it rapidly gained in popularity in many countries in the post-war period, with Nescafé being the most popular product. Many consumers determined that the convenience in preparing a cup of instant coffee more than made up for a perceived inferior taste. Paralleling (and complementing) the rapid rise of instant coffee was the coffee vending machine, invented in 1947 and multiplying rapidly through the 1950s.

International trade
Brazil remains the largest coffee exporting nation, however Vietnam tripled its exports between 1995 and 1999 and became a major producer of *robusta* seeds. Indonesia is the third-largest coffee exporter overall and the largest producer of washed *arabica* coffee. Organic Honduran coffee is a rapidly growing emerging commodity owing to the Honduran climate and rich soil.

Phytochemistry
The primary psychoactive chemical in coffee is caffeine, an adenosine antagonist that is known for its stimulant effects. Coffee also contains the monoamine oxidase inhibitors β-carboline and harmane, which may contribute to its psychoactivity. In a healthy liver, caffeine is mostly broken down by the hepatic microsomal enzymatic system. The excreted metabolites are mostly paraxanthines-theobromine and theophylline—and a small amount of unchanged caffeine. Therefore, the metabolism of caffeine depends on the state of this enzymatic system of the liver.

Extensive scientific research has been conducted to examine the relationship between coffee consumption and an array of medical conditions. The consensus in the medical community is that moderate regular coffee drinking in healthy individuals is either essentially benign or mildly beneficial. Coffee is no longer thought to be a risk factor for coronary heart disease. A 2012 meta-analysis concluded that people who drank moderate amounts of coffee had a lower rate of heart failure, with the biggest effect found for those who drank more than four cups a day. Moreover, in one study, habitual coffee consumption was associated with improved vascular function.

Polyphenols in coffee have been shown to affect free radicals in vitro, but there is no evidence that this effect occurs in humans. Polyphenol levels vary depending on how beans are roasted as well as for how long. As interpreted by the Linus Pauling Institute and the European Food Safety Authority, dietary polyphenols, such as those ingested by consuming coffee, have little or no direct antioxidant value following ingestion.

5.6.3-*Cocoa*

The cocoa bean, also cacao bean or simply cocoa or cacao, is the dried and fully fermented fatty seed of *Theobroma cacao*, from which cocoa solids and cocoa butter are extracted. They are the basis of chocolate, as well as many Mesoamerican foods such as mole sauce and tejate.

Description

A cocoa pod (fruit) has a rough and leathery rind about 2 to 3 cm thick. It is filled with sweet, mucilaginous pulp with a lemonade like taste enclosing 30 to 50 large seeds that are fairly soft and a pale lavender to dark brownish purple colour. Due to heat build up in the fermentation process, cacao beans lose most of the purplish hue and become mostly brown in color, with an adhered skin which includes the dried remains of the fruity pulp. This skin is released easily after roasting by winnowing. White seeds are found in some rare varieties, usually mixed with purples, and are considered of higher value. Historically, white cacao was cultivated by the Rama people of Nicaragua.

Origin and cultivation

The cacao tree is native to the Americas. It may have originated in the foothills of the Andes in the Amazon and Orinoco basins of South America, current day Colombia and Venezuela, where today, examples of wild cacao still can be found. Cacao trees will grow in a limited geographical zone, of approximately 20 degrees to the north and south of the Equator. Nearly 70% of the world crop today is grown in West Africa. Cocoa was an important commodity in pre-Columbian Mesoamerica. Chocolate was introduced to Europe by the Spaniards, and became a popular beverage by the mid 17th century. They also introduced the cacao tree into the West Indies and the Philippines. It was also introduced into the rest of Asia and into West Africa by Europeans.

More than 3,000,000 tonnes of cocoa are produced each year. The production increased by 131.7% in 30 years, representing a compound annual growth rate of 2.9%. There are three main varieties of cocoa plant: Forastero, Criollo, and Trinitario. The first is the most widely used, comprising 95% of the world production of cocoa. Overall, the highest quality cocoa beans come from the Criollo variety, which is considered a delicacy. Trinitario is a hybrid between Criollo and Forastero varieties. It is considered to be of much higher quality than the latter, but has higher yields and is more resistant to disease than the former.

Uses

Cocoa and its products (including chocolate) are used worldwide. Per capita consumption is poorly understood, with numerous countries claiming the highest: various reports state that Switzerland, Belgium, and the UK have the highest consumption.

Production

There were 3.54 million tonnes of cocoa beans produced in the 2008–2009 growing year, which runs from October to September. Of this total, African nations produced 2.45 million tonnes (69%), Asia and Oceania produced 0.61 million tonnes (17%) and the Americas produced 0.48 million tonnes (14%). Two African nations, Côte d'Ivoire and Ghana, produce more than half of the world's cocoa, with 1.23 and 0.73 million tonnes respectively (35% and 21%, respectively). Indonesia is the world’s second largest producer of cocoa.

A typical pod contains 20 to 50 beans and about 400 dried beans are required to make one pound - or 880 per kilogram - of chocolate. Cocoa pods weigh an average of 400 grams and each one yields 35 to 40 grams dried beans (this yield is 40–44% of the total weight in the pod). It is estimated one person can separate the beans from 2000 pods per day.

The wet beans are then transported to a facility so they can be fermented and dried. The beans should be dry for shipment (usually by sea). Traditionally exported in jute bags, over the last decade, beans are increasingly shipped in 'Mega-Bulk' bulk parcels of several thousand tonnes at a time on ships, or in smaller lots of around 25 tonnes in 20 foot containers. Shipping in bulk significantly reduces handling costs; shipment in bags, however, either in a ship's hold or in containers, is still common.

Processing

To make 1 kg of chocolate, about 300 to 600 beans are processed, depending on the desired cocoa content. In a factory, the beans are roasted. Next they are cracked and then de-shelled by a "winnower". The resulting pieces of beans are called nibs. They are sometimes sold in small packages at specialty stores and markets to be used in cooking, snacking, and chocolate dishes. Since nibs are directly from the cocoa tree, they contain high amounts of theobromine. Most nibs are ground, using various methods, into a thick creamy paste, known as chocolate liquor or cocoa paste. This "liquor" is then further processed into chocolate by mixing in (more) cocoa butter and sugar (and sometimes vanilla and lecithin as an emulsifier), and then refined, conched and tempered. Alternatively, it can be separated into cocoa powder and cocoa butter using a hydraulic press or the Broma process. This process produces around 50% cocoa butter and 50% cocoa powder. Standard cocoa powder has a fat content of approximately 10–12 percent. Cocoa butter is used in chocolate bar manufacture, other confectionery, soaps, and cosmetics.

Nutritional value

In general cocoa is considered to be a rich source of antioxidants such as procyanidins and flavanoids, which may impart anti aging properties. Cocoa also contains a high level of flavonoids, specifically epicatechin, which may have beneficial cardiovascular effects on health. The stimulant activity of cocoa comes from the compound theobromine which is less diuretic as compared to theophylline found in tea. Prolonged intake of flavanol-rich cocoa has been linked to cardiovascular health benefits, though it should be noted that this refers to raw cocoa and to a lesser extent, dark chocolate, since flavonoids degrade during cooking and alkalizing processes.

A 15-year study of elderly men published in 2006 found a 50 percent reduction in *cardiovascular* mortality and a 47 percent reduction in *all-cause* mortality for the men regularly consuming the most cocoa, compared to those consuming the least cocoa from all sources. It is believed that the improved blood flow after consumption of flavanol-rich cocoa may help to achieve health benefits in hearts and other organs. In particular, the benefits may extend to the brain and have important implications for learning and memory.

International trade

There are Fair trade cocoa producer groups in Belize, Bolivia, Cameroon, The Congo, Costa Rica, Dominican Republic, Ecuador, Ghana, Haiti, India, Côte d'Ivoire, Nicaragua, Panama, Peru, Sierra Leone and Sao Tome & Principe. As of 2014, less than 1% of the chocolate market was Fair Trade. Cadbury, one of the world's largest chocolate companies, has begun certifying its Dairy Milk bars as Fair Trade.

Cocoa beans, cocoa butter and cocoa powder are traded on two world exchanges: ICE Futures U.S. and NYSE Liffe Futures and Options. The London market is based on West African cocoa and New York on cocoa predominantly from Southeast Asia. Cocoa is the world's smallest soft commodity market.

The future price of cocoa butter and cocoa powder is determined by multiplying the bean price by a ratio. The combined butter and powder ratio has tended to be around 3.5. If the combined ratio falls below 3.2 or so, production ceases to be economically viable and some factories cease extraction of butter and powder and trade exclusively in cocoa liquor.

Cocoa beans can be held in storage for several years in bags or in bulk, during which the ownership can change several times, as the cocoa is traded much the same as metal or other commodities, to gain profit for the owner.

5.7 SUMMARY

Aconitum spp. are considered as the queen of all poisons is a genus of over 250 species. Most species are extremely poisonous and must be dealt carefully. *Atropa belladonna* (Deadly Nightshade) is also known for its toxic properties. It has been used as a poison and a recreational drug. The cinchona - a large shrub or small tree of South American origin- its bark, also known as Peruvian Bark or Jesuit's Bark, is renowned for its medicinal properties. It produces a number of alkaloids, of which the most valuable is quinine, a drug used to treat malaria, which according to a report of the Commissions of Medical Officers of the Government in India, possesses "more than any other that can be named, the confidence of medical practitioners [in India]". Rauwolfia alkaloids belong to the general class of medicines called antihypertensives. They are used to treat high blood pressure (hypertension). Rauwolfia alkaloids may also be used to treat other conditions as determined by your doctor. Ephedra is used for weight loss and obesity and to enhance athletic performance. It is also used for allergies and hay fever; nasal congestion; and respiratory tract conditions such as bronchospasm, asthma, and bronchitis. It is also used for colds, flu, swine flu, fever, chills, headache, inability to sweat, joint and bone pain, and as a "water pill" to increase urine flow in people who retain fluids

Castor (*Ricinus communis*), is the sole species in the monotypic genus, *Ricinus*. Castor seed is the source of castor oil, which has a wide variety of uses. Methanolic extracts of the leaves of *Ricinus communis* has antimicrobial properties. Antihistamine and anti-inflammatory properties were found in ethanolic extract of *Ricinus communis* root bark. Coconut (*Cocos nucifera*) is the only accepted species in the genus *Cocos*. The term coconut can refer to the entire coconut palm, the seed, or the fruit, which, botanically, is a drupe, not a nut. The popularity of coconut is because of a variety of coconut-derived ingredients—from coconut oil to coconut flour and coconut milk—increasingly being used in home kitchens, restaurants and packaged foods besides the coir, a natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes, mattresses, etc. Linseed (*Linum usitatissimum*) is a food and fibre crop that is grown in cooler regions of the world. The textiles made from flax are known as linen, and traditionally used for bed sheets, underclothes and table linen. The oil is known as linseed oil. In addition to referring to the plant itself, the word "flax" may refer to the unspun fibres of the flax plant. Mustard is an annual herb cultivated as oil seed crop or as vegetable or as fodder, of which, 3 species are known for its condiment value. They are pale yellow or white mustard (*Brassica hirta*), brown mustard (*Brassica juncea*) and black mustard (*Brassica nigra*). The major processed products are mustard powder used in the manufacture of mayonnaise, dried or dehydrated mustard leaves, whole mustard seeds etc. Whole mustard is used as a flavouring agent in Indian cooking, whereas ground mustard provides flavour and consistency in Bengali fish curries. Peanut, also known as groundnut (*Arachis hypogaea*) is a crop of global importance. It is widely grown in the tropics and subtropics, being important to both smallholder and large commercial producers. It is classified as both a grain legume, and, because of its high oil content, an oil crop.

The market for beverages is broadly divided in many countries into those products that are bought to quench thirst, and those that are consumed on special occasions including festivals. The former group are mostly nonalcoholic and include tea, coffee, and cocoa. Competition from medium/large-scale producers is most acute for small-scale producers in beverage manufacture. Many large-scale producers promote their products by implying status in their consumption and spend considerable amounts on advertising and packaging. They may also have established sophisticated distribution systems and specific agreements with wholesalers and retailers. Thus beverage manufacture is one of the most difficult for small-scale producers to establish and succeed in.

5.8 GLOSSARY

Analgesic: A drug characterized by its ability to relieve pain.

Antioxidant: An agent that inhibits oxidation. May reduce risks of contracting certain diseases.

Astringent: A drug characterized for its ability to draw together skin or mucous membranes.

Laxative: A substance that, when ingested, has the property of loosening the bowels.

Resin: A vegetable product obtained from secretions of fir and juniper plants used in making varnish and adhesives.

Tannins: An astringent substance found in some plants possessing the property of turning animal hide into leather.

Tincture: An infusion.

Canola oil: Rapeseed oil, specifically that prepared from rapeseed plants bred to be low in erucic acid.

Castor oil: A fixed oil obtained from the seed of *Ricinus communis;* used as a bland topical emollient and also occasionally as a strong cathartic.

Peanut oil: (Ground nut oil), a clear oil with some applications as a salad dressing, and, due to its high smoke point, especially used for frying.

Coconut oil: Cooking oil, with medical and industrial applications as well. Extracted from the kernel or meat of the fruit of the coconut palm. Common in the tropics and unusual in composition, with medium chain fatty acids dominant.

Flaxseed oil: (called linseed oil when used as a drying oil), from the seeds of *Linum usitatissimum*. High in omega-3 and lignans, which can be used medicinally. A good dietary equivalent to fish oil. Easily turns rancid.

Mustard oil : (pressed), used in India as a cooking oil. Also used as a massage oil.

Aged coffee: Certain coffees from the Asia/Pacific region benefit from prolonged storage prior to roasting. After ageing for three to five years, these coffees develop a unique cedar-spice flavour and are used in select Starbucks blends, including Starbucks® Christmas Blend.

Arabica: One of the two major commercially significant species of coffee. The only one purchased by Starbucks.

Berry: A flavour and aroma reminiscent of blackberries or blueberries. Some of the best coffees of East Africa and the Arabian Peninsula have these characteristics.

Blend: A coffee such as Caffè Verona® that combines coffees from different origin countries to achieve a taste that no single origin coffee can offer

Organic coffees: Coffee grown without the use of synthetic pesticides, herbicides or chemical fertilisers can be certified organic. They must also be processed in mills and roasting facilities that are certified organic.

Processing: The method in which the fruit of the coffee cherry is separated from the green coffee bean.

Robusta: One of the two major commercially significant species of coffee. Grown at lower altitudes than arabicas. The flavour is less refined and the caffeine content is higher. Starbucks does not purchase robusta coffees

Astringent: A tea tasting term which describes a liquor which is pungent but inclined to be acidic

Black Tea: The most commonly consumed tea in the world accounting for approximately 80% of all consumption. In the United States well over 90% of the tea consumed is black. One of three major types of tea, the others being Green and Oolong. Black teas are the most processed of all teas in that they are oxidized or fermented.

Caffeine: A component of tea which stimulates the nervous system. A cup of tea averages 40 milligrams of caffeine versus approximately 110 in a cup of coffee

Darjeeling tea: A very high quality black tea grown in the Himalayan Mountains in Northern India. Called the champagne of teas.

Fermentation: A term used to describe the processing of Oolong and Black teas. The actual chemical transformation which takes place is actually oxidation.

Green tea: Tea which undergoes minimal processing and most resembles the original green leaf.

Imperial Tea: A rolled Green Tea from Ceylon, China, or India made from older leaves. It has a g: Developed in the 1930's and commercialized in the 50's, instant tea sacrifices nuances in fragrance and flavor for convenience

Organoleptic: The process used by most tea tasters to evaluate the quality of a tea using all the senses

Tea: The leaf and extracted liquor of the shrub Camellia sinensis. No other beverages merit the unqualified term tea

Cocoa: A texture and flavour reminiscent of unsweetened cocoa powder. It leaves a somewhat dry but very pleasant aftertaste in the mouth

Cocoa Bean: The seed of the cacao tree, which is only called a cocoa bean once it is removed from the pod in which it grows.

Cocoa Pod: The leathery oval pod that contains cocoa beans.

Conching: Part of the process by which chocolate is manufactured. Cocoa liquor, cocoa butter and sugar are blended and placed in large agitators, called 'conches' that stir the mixture under heat.

Forastero Cocoa Beans: The most commonly grown and used beans. These beans make up about 90 percent of the world's production and are grown primarily in West Africa.

5.9 SELF ASSESSMENT QUESTIONS

5.9.1 Short answer type questions:

1. Distribution and diversity of *Aconitum* species.
2. Medicinal uses of Belladona.
3. Historical perspective of medicinal uses of *Cinchona.*
4. How is cinchona bark testing is related to the birth of Homeopathy?
5. Different alkaloids found in *Rauvolfia serpentine.*
6. Traditional uses of *Ephedra* for a variety of medicinal purposes.
7. Major oil yielding plant species.
8. Beside oil, coconut is and essential element of rituals in Hindu tradition. Illustrate.
9. Importance of linseed as a food and fibre crop.
10. Domestication and production of groundnut.
11. World output of rapeseed & mustards.
12. General account of beverages with special reference to tea, coffee and cocoa.

5.9.2 Multiple choice questions:

1. The "Queen of all Poisons" is-

(a) Atropa (b) Aconitum
(b) Ephedra (d) Cinchona

2. "Deadly Nightshade" is-

(a) Aconitum (b) Rauwolfia
(c) Atropa (d) Ephedra

3. *Cinchona* is native to-

(a) Africa (b) Asia
(c)Australia (d) South America

4. Performance enhancing drugs in sports is-
(a) Aconitum (b) Ephedra
(c) Atropa (d) Rauwolfia

5. Botanically, the coconut fruit is a-
(a) Drupe (b) Nut
(c) Berry (d) None of the above

6. Flax was domesticated in-
(a) Fertile Crescent region (b) Andean hills
(c) Ethiopia (d) India

7. The domesticated peanut is a-
(a) Diploid (b) Polyploid
(c) Tetraploid (d) Amphidiploid

8. The largest producers of peanut is-
(a) USA (b) India
(c) Argentina (d) Brazil

9. The Indian state occupying first place both in terms of cultivated area and production of mustard is –
(a) Madhya Pradesh (b) Haryana
(c) Rajasthan (d) Uttar Pradesh

10. The world leader in production of tea is-
(a) People's Republic of China (b) India
(c) Sri Lanka (d) Kenya

11. The world leader in production of green coffee is-
(a) Vietnam (b) Indonesia
(c) Brazil (d) Colombia

12. The largest producer of washed *arabica* coffee-
(a) Brazil (b) Honduras
(c) Vietnam (d) Indonesia

13. The cacao tree is native to the-
(a) Europe (b) Americas
(c) Africa (d) Asia

14. The highest cocoa beans are produced by-

(a) African nations	(b) Asia
(c) Americas	(d) Oceania

15. In general cocoa is considered to be a rich source of-

(a) Polysaccharides	(b) Proteins
(c) Fats	(d) Antioxidants

5.9.2: Answers Key: 1-(b), 2-(c), 3-(d), 4-(b), 5-(a), 6-(a), 7-(d), 8-(b), 9-(c), 10-(a). 11-(c), 12-(d), 13-(b), 14-(a), 15-(d)

5.10 REFERENCES

- Chappuis, E. (2014). "*Aconitum napellus*". *IUCN Red List of Threatened Species. Version 2014.2*. International Union for Conservation of Nature. Retrieved 28 August 2014.
- J Ethnopharmacol. 1981 Nov;4(3):247-336. *Arrow poisons in China. Part II. Aconitum--botany, chemistry, and pharmacology*. Bisset NG.
- Roberts, M. F., and Michael Wink. 1998. *Alkaloids biochemistry, ecology, and medicinal applications*. New York: Plenum Press. Page 18.
- Chyka PA, Seger D, Krenzelok EP, Vale JA (2005). "Position paper: Single-dose activated charcoal". *Clin Toxicol (Phila)* 43 (2): 61–87. PMID 15822758.
- Lin CC, Chan TY, Deng JF (May 2004). "Clinical features and management of herb-induced aconitine poisoning". *Ann Emerg Med* 43 (5): 574–9. doi:10.1016/j.annemergmed.2003.10.046. PMID 15111916.
- Mallinson T (2010). "Deadly Nightshade: *Atropa Belladonna*". *Focus on First Aid* (15): 5.
- Lee MR (March 2007). "Solanaceae IV: Atropa belladonna, deadly nightshade" (PDF). *J R Coll Physicians Edinb* **37** (1): 77–84. PMID 17575737.
- Potter, Samuel O.L. (1893). *A Handbook of Materia Medica Pharmacy and Therapeutics*. London: P. Blakiston's. p. 53.
- Hardy TK, Wakely D (1962). "The amnesic properties of hyoscine and atropine in pre-anæsthetic medication". *Anaesthesia* **17** (3): 331–336. doi:10.1111/j.1365-2044.1962.tb13473.x. PMID 13904669.
- Motley, Cheryl. "Cinchona and its product--Quinine". *Ethnobotanical leaflets*. Southern Illinois University Herbarium. Retrieved 11 June 2010.
- *Guidelines for the treatment of malaria. Second edition* March 2010, World Health Organization*, 2010. Available on-line at: WHO Document centre*
- Paul Reiter (2000) "From Shakespeare to Defoe: Malaria in England in the Little Ice Age," *Emerging Infectious Diseases*, **6** (1) : 1-11. Available on-line at: National Center for Biotechnology Information.

- Robert Talbor (1672) *Pyretologia: a Rational Account of the Cause and Cures of Agues.*
- Robert Talbor (1682) *The English Remedy: Talbor's Wonderful Secret for Curing of Agues and Feavers.*
- Joseph P. Remington, Horatio C. Wood, ed. (1918). "Cinchona". *The Dispensatory of the United States of America*.
- Alfred Baring Garrod (2007). "Cinchonaceae. Part 2". *Essentials Of Materia Medica And Therapeutics*. Kessinger Publishing. ISBN 1-4326-8837-5.
- "Quinine". *Encyclopaedia Britannica* (10 ed.). 1902.
- Druilhe, P. et al. "Activity of a combination of three *Cinchona* bark alkaloids against *Plasmodium falciparum in vitro*". *Antimicrobial Agents and Chemotherapy* **32** (2): 250–254. doi:10.1128/aac.32.2.250.
- Oudhia, P. and Tripathi, R.S. (2002).Identification, cultivation and export of important medicinal plants. In Proc. National Seminar on Horticulture Development in Chhattisgarh: Vision and Vistas. Indira Gandhi Agricultural University, Raipur (India) 21-23 Jan. 2002:78-85.
- Sumit Isharwal and Shubham Gupta (2006). "Rustom Jal Vakil: his contributions to cardiology". *Texas Heart Institute Journal* **33** (2): 161–170. PMC 1524711. PMID 16878618.
- Gurley B, Wang P, Gardner S (1998). "Ephedrine-type alkaloid content of nutritional supplements containing Ephedra sinica (Ma-huang) as determined by high performance liquid chromatography". *J Pharm Sci* 87 (12): 1547–53. doi:10.1021/js9801844. PMID 10189265.
- Botany of Haoma, from Encyclopedia Iranica. Accessed March 15, 2007.
- Abourashed E, El-Alfy A, Khan I, Walker L (2003). "Ephedra in perspective--a current review". *Phytother Res* **17** (7): 703–12. doi:10.1002/ptr.1337. PMID 12916063.
- Kee C. Huang (12 December 2010). *The Pharmacology of Chinese Herbs, Second Edition*. CRC Press. p. 9. ISBN 978-1-4200-4826-1.
- Abourashed, Ehab A.; Abir T. El-Alfy; Ikhlas A. Khan; Larry Walker (2003). "Ephedra in perspective – a current review" (PDF). *Phytotherapy Research* **17** (7): 703–712. doi:10.1002/ptr.1337. PMID 12916063.
- Bohn A, Khodaee M, Schwenk T (2003). "Ephedrine and other stimulants as ergogenic aids". *Curr Sports Med Rep* 2 (4): 220–5. doi:10.1007/s11932-003-0009-2. PMID 12834578.
- Calfee R, Fadale P (2006). "Popular ergogenic drugs and supplements in young athletes". *Pediatrics* 117 (3): e577–89. doi:10.1542/peds.2005-1429. PMID 16510635.
- Barker W, Antia U (2007). "A study of the use of Ephedra in the manufacture of methamphetamine". *Forensic Sci Int* 166 (2–3): 102–9. doi:10.1016/j.forsciint.2006.04.005. PMID 16707238.
- Haller C, Duan M, Benowitz N, Jacob P (2004). "Concentrations of ephedra alkaloids and caffeine in commercial dietary supplements". *J Anal Toxicol* 28 (3): 145–51. doi:10.1093/jat/28.3.145. PMID 15107143.

- Wolfe S (2003). "Medicine. Ephedra--scientific evidence versus money/politics". *Science* 300 (5618): 437. doi:10.1126/science.1081910. PMID 12702860.
- Shekelle P, Hardy M, Morton S, Maglione M, Mojica W, Suttorp M, Rhodes S, Jungvig L, Gagné J (2003). "Efficacy and safety of ephedra and ephedrine for weight loss and athletic performance: a meta-analysis". *JAMA* 289 (12): 1537–45. doi:10.1001/jama.289.12.1537. PMID 12672771.
- Oyewole O.I., Owoseni A.A., Faboro E.O. (2010). "Studies on medicinal and toxicological properties of *Cajanus cajan*, *Ricinus communis* and *Thymus vulgaris* leaf extracts". *Journal of Medicinal Plant Research* 4 (19): 2004–8. doi:10.5897/JMPR10.363. ISSN 1996-0875.
- Irwin R (March 1982). "NTP technical report on the toxicity studies of Castor Oil (CAS No. 8001-79-4) In F344/N Rats And B6C3F1 Mice (Dosed Feed Studies)". *Toxic Rep Ser* 12: 1–B5. PMID 12209174.
- Tan Q.-G., Cai X.-H., Dua Z.-Z., Luo X.-D. (2009). "Three terpenoids and a tocopherol-related compound from *Ricinus communis*". *Helvetica Chimica Acta* 92 (12): 2762–8. doi:10.1002/hlca.200900105.
- Allaby, R.; Peterson, G.; Merriwether, D.; Fu, Y.-B. (2005). "Evidence of the domestication history of flax (*Linum usitatissimum* L.) from genetic diversity of the sad2 locus". *Theoretical and Applied Genetics* 112 (1): 58–65. doi:10.1007/s00122-005-0103-3.
- Balter, M (2009). "Clothes make the (Hu) Man". *Science* 325 (5946): 1329. doi:*10.1126/science.325_1329a. PMID 19745126.*
- Kvavadze E, Bar-Yosef O, Belfer-Cohen A, Boaretto E, Jakeli N, Matskevich Z, Meshveliani T. (2009).30,000-Year-Old Wild Flax Fibers. *Science*, 325(5946):1359. doi:10.1126/science.1175404 PMID 19745144 Supporting Online Material
- Fu, Y.-B. (2011). "Genetic evidence for early flax domestication with capsular dehiscence". *Genetic Resources and Crop Evolution* 58 (8): 1119–1128. doi:10.1007/s10722-010-9650-9.
- Barber E. (1991) "Prehistoric Textiles: The Development of Cloth in the Neolithic and Bronze Ages with Special Reference to the Aegean". Princeton University Press, p.12
- McHughen, A (1990). "Flax (Linum usitatissimum L.): In Vitro Studies". *Biotechnology in Agriculture and Forestry* 10: 502–514. doi:10.1007/978-3-642-74448-8_24.
- Cunnane SC, Ganguli S, Menard C, Liede AC, Hamadeh MJ, Chen ZY, Wolever TM, Jenkins DJ (1993). "High alpha-linolenic acid flaxseed (*Linum usitatissimum*): some nutritional properties in humans". *Br J Nutr* 69 (2): 443–53. doi:10.1079/bjn19930046. PMID 8098222.
- Singh KK, Mridula D, Rehal J, Barnwal P (2011). "Flaxseed: a potential source of food, feed and fiber". *Crit Rev Food Sci Nutr* 51 (3): 210–22. doi:10.1080/10408390903537241. PMID 21390942.
- Wardey, A. J. (1967). *The Linen Trade: Ancient and Modern*. Routledge. p. 752. ISBN 0-7146-1114-X.

- Lopes RM, Agostini-Costa Tda S, Gimenes MA, Silveira D (2011). "Chemical composition and biological activities of Arachis species". *J Agric Food Chem* 59 (9): 4321–30. doi:10.1021/jf104663z. PMID 21425852.
- Ozcan MM (2010). "Some nutritional characteristics of kernel and oil of peanut (Arachis hypogaea L.)". *J Oleo Sci* 59 (1): 1–5. PMID 20032593.
- Handy, R.B. 1895. Peanuts: Culture and Uses. USDA Farmers' Bulletin 25.
- Rich, J.P. (1915). Uses of the Peanut on the Home Table. Farmer's Bulletin 13. University of Texas, Austin.
- Carver, G.W. (1925). How to Grow the Peanut and 105 Ways of Preparing it for Human Consumption. Tuskegee Institute Experimental Station Bulletin 31.
- Smith, C. Wayne (1995) "Crop Production: Evolution, History, and Technology", John Wiley & Sons, pp. 412–413 ISBN 0-471-07972-3
- Grubben, G.J.H. & Denton, O.A. (2004) Plant Resources of Tropical Africa 2. Vegetables. PROTA Foundation, Wageningen; Backhuys, Leiden; CTA, Wageningen.
- "Sarson Ka Saag". Retrieved 14 February 2014.
- Chandrassekaran, V. K. (February 24, 2013). "Flavour of Punjab". *The Hindu*. Retrieved 6 March 2013.
- Mary Lou Heiss; Robert J. Heiss (23 March 2011). *The Story of Tea: A Cultural History and Drinking Guide*. Random House. p. 31. ISBN 978-1-60774-172-5. By the time of the Shang dynasty (1766–1050 BC), tea was being consumed in Yunnan Province for its medicinal properties
- Bennett Alan Weinberg; Bonnie K. Bealer (2001). *The World of Caffeine: The Science and Culture of the World's Most Popular Drug*. Psychology Press. p. 63. ISBN 978-0-415-92722-2. The Portuguese traders and the Portuguese Jesuit priests, who like Jesuits of every nation busied themselves with the affairs of caffeine, wrote frequently and favorably to compatriots in Europe about tea.
- Mondal, T.K. (2007). "Tea". In Pua, E.C.; Davey, M.R. *Biotechnology in Agriculture and Forestry*. 60: Transgenic Crops V. Berlin: Springer. pp. 519–520. ISBN 3-540-49160-0.
- Harler, Campbell Ronald (2014-08-26). "Tea production". *Encyclopædia Britannica*. Retrieved June 2007.
- Yang, CS; Chen, G; Wu, Q (2014). "Recent scientific studies of a traditional Chinese medicine, tea, on prevention of chronic diseases". *J Tradit Complement Med* 4 (1): 17–23. doi:10.4103/2225-4110.124326. PMID 24872929.edit
- Cornelis, MC; El-Sohemy, A (2007). "Coffee, caffeine, and coronary heart disease". *Current Opinion in Clinical Nutrition and Metabolic Care* 10 (6): 745–751. doi:10.1097/MCO.0b013e3282f05d81. PMID 18089957.
- Wild, Antony (2004-03-25). *Coffee: A dark history*. pp. 217–229. ISBN 9781841156491.
- Ukers, William (1935). *All About Coffee*. New York: Tea & Coffee Trade Journal Company. pp. 9–10.

- Cousin, Tracey L (June 1997). "Ethiopia Coffee and Trade". American University. Retrieved March 18, 2008.
- Duke, James A. (1983). "Coffea arabica L.". Purdue University. Retrieved January 4, 2010.
- Hamon, S; Noirot, M; Anthony, F (1995). "Developing a coffee core collection using the principal components score strategy with quantitative data" (PDF). *Core Collections of Plant Genetic Resources* (Wiley-Sayce Co). Retrieved January 4, 2010.
- Belachew, Mekete (2003). "Coffee". In Uhlig, Siegbert. *Encyclopaedia Aethiopica* 1. Wiesbaden: Harrassowitz. p. 763.
- Benoit Daviron; Stefano Ponte (2005). *The Coffee Paradox: Global Markets, Commodity Trade and the Elusive Promise of Development*. Zed Books. p. 51. ISBN 978-1-84277-457-1.
- "Coffee: World Markets and Trade" (PDF). *Foreign Agricultural Service Office of Global Analysis*. United States Department of Agriculture. December 2009. Retrieved March 26, 2010.
- Davids, Kenneth (2001). *Coffee: A Guide to Buying, Brewing, and Enjoying* (5th ed.). New York: St. Martin's Griffin. ISBN 0-312-24665-X.
- Smith, A (2002). "Effects of caffeine on human behavior". *Food and Chemical Toxicology* 40 (9): 1243–1255 (1245, 1249). doi:10.1016/S0278-6915(02)00096-0. PMID 12204388. Retrieved February 12, 2010.
- Butt, M.S.; Sultan, M.T. (2011). "Coffee and its consumption: benefits and risks". *Critical Reviews in Food Science and Nutrition* 51 (4): 363–373. doi:10.1080/10408390903586412. PMID 21432699.
- Verlengia F, Rigitano A, Nery JP, Tosello A. Variations of the caffeine content in coffee beverages. ASIC, 2nd Int Sci Colloq Green and Roasted Coffee Chem. 1965, 106–114:
- Wood, G.A.R.; Lass, R.A. (2001). *Cocoa* (4th ed.). Oxford: Blackwell Science. p. 2. ISBN 063206398X.
- "Cocoa Market Update" (PDF). World Cocoa Foundation. May 2010. Retrieved 11 December 2011.
- Wood, G. A. R.; Lass, R. A. (2001). *Cocoa*. Tropical agriculture serie (4 ed.). John Wiley and Sons. ISBN 0-632-06398-X.
- Dand, Robin (1999). *The international cocoa trade* (2 ed.). Woodhead Publishing. ISBN 1-85573-434-6.
- "Cocoa: From Bean to Bar," Urbanski, John, Food Product Design, May 2008
- J.B. Keogh, J. McInerney, and P.M. Clifton: "The Effect of Milk Protein on the Bioavailability of Cocoa Polyphenols", *Journal of Food Science* 72(3)S230-S233, 2007. Downloaded from http://onlinelibrary.wiley.com/doi/10.1111/j.1750-3841.2007.00314.x/abstract
- Buijsse B, Feskens EJ, Kok FJ, Kromhout D (February 2006). "Cocoa intake, blood pressure, and cardiovascular mortality: the Zutphen Elderly Study". *Arch. Intern. Med.* 166 (4): 411–7. doi:10.1001/archinte.166.4.411. PMID 16505260.

- Sudarsan Raghavan and Sumana Chatterjee (24 June 2001). "Slaves feed world's taste for chocolate: Captives common in cocoa farms of Africa". Milwaukee Journal Sentinel. Archived from the original on 17 September 2006. Retrieved 25 April 2012.
- "Combating Child Labour in Cocoa Growing" (PDF). International Labor Organization. 2005. Retrieved 26 April 2012.
- Oke, D.O.; Odebiyi, K.A. (2007). "Traditional cocoa-based agroforestry and forest species conservation in Ondo State, Nigeria, Agriculture". *Ecosystems & Environment* **122** (3): 305–311. doi:10.1016/j.agee.2007.01.022.
- Beluhan, S. and Ranogajec, A. Chemical composition and non-volatile components of Croatian wild edible mushrooms. Food Chemistry, 2010; 124: 1435-1452.
- Food and Agriculture Organization of the United Nations (FAO). Annual Report: The state of food insecurity in the world, monitoring the progress towards the world food summit and millennium development goals, Rome, 2004.
- Bharucha Z, Pretty J. The roles and values of wild foods in agricultural systems. Phil Trans Royal Soc B., 2010; 365: 2913-2926. http://dx.doi.org/10.1098/rstb.2010.0123
- FAO. 2009a. Declaration of the World Summit on Food, Rome, 16-18 November 2009. Food and Agriculture Organization of the United Nations. Rome, Italy. Available at: http://www.fao.org/fileadmin/templates/wsfs/Summit/Docs/Final_Declaration/WSFS09_Declaration.pdf.
- Mehta, P.S., Negi, K.S. and Ojha, S.N. Native plant genetic resources and traditional foods of Uttarakhand Himalaya for sustainable food security and livelihood. Indian J. Nat. Prod. Resour. 2010. 1(1): 89-96. IF- 4.08 (NAAS); Citation-46.
- Upreti, B.M., Tewari, L.M. and Tewari, S. Role of Plants Used in Religious and Cultural System by Local Inhabitants of Sacred Forests of district Pithoragarh, Kumaun Himalaya. *Biolife*, 2017; 5(1): 7-11. doi:10.17812/blj.2017.5102.
- Upreti, K., Tewari, L.M., Pangtey, Y.P.S. and Jalal, J.S. Diversity and Distribution of Wild Edible Fruit Plants of Uttarakhand, Biodiversity Potentials of the Himalaya Edited by: Tewari, L.M., Pangtey, Y.P.S. and Tewari, G. 2010 Gyanodaya Prakashan, Nainital, 2010; 157 – 196.

5.11 SUGGESTED READINGS

- Rita P., Animesh D.K. "An updated overview on *Atropa belladonna* L" (PDF). International Research Journal of Pharmacy.
- Berdai, Mohamed Adnane; Labib, Smael; Chetouani, Khadija; Harandou, Mustapha (17 April 2012). "Atropa Belladonna intoxication: a case report". *Pan African Medical Journal* 11: 72. PMID 22655106. Retrieved 1 May 2015.
- Mair, Victor H.; Hoh, Erling (2009). *The True History of Tea*. Thames & Hudson. ISBN 978-0-500-25146-1.

- Martin, Laura C. (2007). *Tea: The Drink that Changed the World*. Tuttle Publishing. ISBN 0-8048-3724-4.
- Claud Bald: Indian Tea. *A Textbook on the Culture and Manufacture of Tea*. Fifth Edition. Thoroughly Revised and Partly Rewritten by C. J. Harrison. Thacker, Spink & Co., Calcutta 1940 (first edition, 1933).
- Kit Chow, Ione Kramer (1990): *All the Tea in China*, China Books & Periodicals Inc. ISBN 0-8351-2194-1.
- John C. Evans (1992): *Tea in China: The History of China's National Drink*, Greenwood Press. ISBN 0-313-28049-5
- Harler, C. R., *The Culture and Marketing of Tea*. Second edition. Oxford University Press, New York and Bombay, Reprinted 1958 (First edition 1933, second edition 1956).
- Eelco Hesse (1982), *Tea: The eyelids of Bodhidharma*, Prism Press.
- Hobhouse, Henry (2005). "Seeds of Change: Six Plants that Transformed Mankind". Shoemaker & Hoard. ISBN 1-59376-049-3.
- Nye, Gideon (1850). *Tea: and the tea trade Parts first and second*. New York: Printed by G. W. Wood.
- Lester Packer; Choon Nam Ong; Barry Halliwell (2004): *Herbal and Traditional Medicine: Molecular Aspects of Health*, CRC Press, ISBN 0-8247-5436-0.
- Jane Pettigrew (2002), *A Social History of Tea*
- Jane Pettigrew (1999), *Tea & Infusions: a connoisseur's guide*. Carlton Books.
- Pettigrew, Jane & Richardson, Bruce (2005). *The New Tea Companion: a guide to teas throughout the world*. Benjamin Press. ISBN 0-9663478-3-8.
- James Norwood Pratt (2005), *Tea Dictionary*
- Tunstall-Pedoe, M.; Tunstall-Pedoe, H. (1999). "Coffee and tea consumption in the Scottish Heart Health Study follow up: conflicting relations with coronary risk factors, coronary disease, and all cause mortality". *Journal of epidemiology and community health* **53** (8): 481–487. doi:10.1136/jech.53.8.481. PMC 1756940. PMID 10562866.
- Yang CS, CS (November–December 1999). "Tea and Health". *Nutrition (Burbank, Los Angeles County, Calif.)* **15** (11–12): 946–949. doi:10.1016/S0899-9007(99)00190-2. PMID 10575676.
- Allen, Stewart Lee (1999). *The Devil's Cup: Coffee, the Driving Force in History*. Soho: Random House. ISBN 1-56947-174-6.
- Bersten, Ian (1999). *Coffee, Sex & Health: A History of Anti-coffee Crusaders and Sexual Hysteria*. Sydney: Helian Books. ISBN 0-9577581-0-3.
- Clarke, Ronald James; Macrae, R, eds. (1987). *Coffee*. 2: Technology. Barking, Essex: Elsevier Applied Science. ISBN 1-85166-034-8.
- Clifford, M. N.; Wilson, K. C., eds. (1985). *Coffee: Botany, Biochemistry and Production of Beans and Beverage*. Westport, Connecticut: AVI Publishing. ISBN 0-7099-0787-7.

- Ganchy, Sally (2009). *Islam and Science, Medicine, and Technology*. The Rosen Publishing Group. ISBN 1-4358-5066-1.
- Hünersdorff, Richard von & Hasenkamp, Holger G. (2002) *Coffee: a bibliography : a guide to the literature on coffee* London: Hünersdorff
- Jacob, Heinrich Eduard (1998). *Coffee: The Epic of a Commodity*. Short Hills, N.J.: Burford Books. ISBN 978-1-58080-070-9.
- Kummer, Corby (August 19, 2003). *The Joy of Coffee: The Essential guide to Buying, Brewing, and Enjoying*. Boston: Houghton Mifflin. ISBN 0-618-30240-9.
- Luttinger, Nina and Dicum, Gregory. *The Coffee Book: Anatomy of an Industry from Crop to the Last Drop*(Bazaar Book, 2006)
- Metcalf, Allan A (1999). *The World in So Many Words: A Country-by-country Tour of Words that have Shaped our Language*. Houghton Mifflin. ISBN 0-395-95920-9.
- Pendergrast, Mark (2001) [1999]. *Uncommon Grounds: The History of Coffee and How It Transformed Our World*. London: Texere. ISBN 1-58799-088-1.
- Rao, Scott. *The Professional Barista's Handbook*.
- Siasos, G.; Oikonomou, E.; Chrysohoou, C.; Tousoulis, D.; Panagiotakos, D.; Zaromitidou, M.; Zisimos, K.; Kokkou, E.; Marinos, G.; Papavassiliou, A. G.; Pitsavos, C.; Stefanadis, C. (2013). "Consumption of a boiled Greek type of coffee is associated with improved endothelial function: The Ikaria Study". *Vascular Medicine* **18** (2): 55–62. doi:10.1177/1358863X13480258. PMID 23509088.
- Siasos G, Tousoulis D, Stefanadis C; Tousoulis; Stefanadis (February 2014). "Effects of habitual coffee consumption on vascular function". *Journal of the American College of Cardiology* **63** (6): 606–607. doi:10.1016/j.jacc.2013.08.1642. PMID 24184234.
- Weinberg, Bennett Alan; Bealer, Bonnie K (2001). *The World of Caffeine: The Science and Culture of the World's Most Popular Drug*. New York: Routledge. ISBN 0-415-92722-6.
- Weissman, Michaele. *God in a Cup: The Obsessive Quest for the Perfect Coffee.*

5.12-TERMINAL QUESTIONS

1. Describe in brief how aconite has long been used in traditional Chinese medicine and Ayurveda (Hindu traditional medicine).
2. Name the toxins *Atropa* contains. What drug is derived from *Atropa* plant.
3. Who originally discovered the medicinal properties of the cinchona tree and in what ways it was used.
4. Describe different variety of uses of castor oil.
5. Name the traditional areas of coconut cultivation in India. Which Indian state has the largest number of coconut trees? Also describe various coconut-based products.
6. Where was linseed domesticated? Describe where it is cultivated most globally.
7. Who are the major producers/exporters of peanuts in the world?

8. Describe the world production and consumption trend of rapeseed and mustard.
9. India is the world's largest tea-drinking nation. What is the per capita consumption of tea per person every year? Name the country that is the world's greatest per capita consumer.
10. Who are the world leaders in production of Arabica and Robusta coffee?
11. Describe the health benefits of consuming cocoa.
12-What are wild edible Plants? Describe with examples.
13-Write a short notes on role of wild edible plants

UNIT-6 SCOPE AND IMPORTANCE OF ETHNOBOTANY

Contents

6.1 OBJECTIVES

After going through this unit student will be able to-

- Define the ethnobotany and know about the scope
- Discuss the historic roots of ethnobotany
- Discuss Ethnic groups of India, their food and food plants
- Explain Ethnobotany and conservation of natural resources
- What are Ethnomedicinal plants
- Discuss about the Narcotic plants

6.2 INTRODUCTION

The term ethanobotany was coined by J.W. Harshberger, an American botanist at the University of Pensylvania, in 1895. Ethanobotany is the systematic study of the relationships between plants and people though initially it was used to describe the study of plants used by primitive and aboriginal people. In other words Ethanobotany means all the sources of the plants towards humankind and the other species growing on the planet. From the ancient time, people have used plants to provide them food, fodder, medicines, clothes, fibers, crafts, dyes, soaps and detergent, dyes, novel compounds, materials for construction.

Ethno (as in ethnic) refers to people, culture, a culture collective body of beliefs, aesthetic, knowledge, language and practice. Botany is the study of plants.

The scope of Ethnobotany is increasing day by day. To describe the field in broader sense ethnobotanists have given their definitions time to time.

Jones (1941) defined Ethnobotany as 'the study of interrelations of primitive man and plants'.

According to Schultes (1962), Ethnobotany is defined as the study of the relationships which exist between plants and people of a primitive society and their plant environment'.

Vartak and Gadgil (1980) suggested 'Ethnobotany is a branch of economic botany, a section of which deals with the role of plants in life and culture of aborigines and tribal people'.

Alcom (1984) states that Ethnobotany is the study of contextualized plant use.

Jain (1987) applied the term Ethnobotany as the total natural and traditional relationship and interaction between man and his surrounding plant wealth. Wickens (1990) defined Ethnobotany as the study of useful plants prior to their commercial exploitation and eventual domestication.

According to ford 1994, Ethanobotany is concerned with a wide range of interest of plants in cultural and ecological context.

Turner (1996) has given an appropriate definition that is "the Science of people's interaction with plants".

Ethanobotany is the use of plants in material or abstract form among ethnic communities or tribal people. Sometimes, it is regarded as ethnographical or anthropological or tribal botany.

Ethanobotany is a combination of ethnography and botany. Ethnographers describe the people of a region including their race, language and their uses of plants.

Ethanobotany is an interdisciplinary science and undertakes a research on the relationship between plants and humans in the areas of: nutrition, education, archaeology, linguistics, healing, paleology, livelihood, medicine, agriculture etc. The scope of the subject has expanded greatly. Botanists, anthropologists, social scientists, and the practitioners of indigenous medicines are engaged in the study of people-plant interactions in natural environment.

6.3 CONCEPT AND HISTORY

The term Ethnobotany was coined by the early 20th century botanist John William Harshberger. The roots of ethnobotanical science can be traced in the ancient Sanskrit, Arabic literatures, Greek, ethnographics, travelogues etc. Vast ethanobotanical knowledge exists in India from ancient time. A variety of uses of plants are mentioned in the ancient Indian Sanskrit literature, e.g. Rigveda, Atharvaveda, Upanishads, Mahabharata and Puranas etc. These include plants used in worships, as medicines, tools of agriculture, food, fuel etc. A list of some of the importance Indian treatises is presented in two vedic periods Rigveda and Athervaveda 148 medicinal plants are included in Charaka Samhita 400-450 medicinal plants are included.

Pent-s'ao, the treatise on herbs written by Emperor Shah Nung has references to 365 drugs. It has also been reported that hundreds of drugs including important species, i.e., henbane, pomegranate, opium, poppy, aloe and onion were commonly used by the Egyptians. Ethanobotany has developed in the recent past into an important scientific discipline. The central issues in the ethnobotanical studies involve the interaction between plants and people and foremost among these are the management of plant diversity by indigenous communities and the traditional use of medicinal plants.

6.4 ETHNIC GROUPS OF INDIA

Ethnic Groups in India

India has been the most ethnically diverse nation on earth for many centuries, with over 200 tribes, sub tribes, and some other ethnic groups. Ethnic categories exist based on language, religion, geographical ancestry and other factors. The following lists of ethnic groups give State wise brief general information on some specify groups.

Uttarakhand: Bhotia, Gangwal, Jodh, Jaunsari, Khaseas (different from Khasia, found in Kumaon), Tharu.

Andhra Pradesh: Andh tribe Bagata (Bagatha), Chenchu, Hill Reddis, Jatapau, Kanmara (Konda), Khond (Konod), Kolam, Kollavaru, Konda-Dhora, Konda-Kapus, Konda-Reddis, Koya, Lambadis (Sugalis), Pardhan, Paroja, Saora, Valmiki, Yenadis, Yerakulas.

Madhya Pradesh: Panika Gond tribe, Abujhmaria, Agariya, Baiga (Panda), Bhaina, Bharias (Bhumia), Bhatra, Bhil, Bhumiya, Binjhal, Binghwar, Birhor, Dhurwa, Gudaba, Gond, Halwa, Hillmaria, Kamar (Kanwar), Khairwar, Khariya, Khond, Kol (Col), Korku, Mahto, Manjhi, Majhwar, Munda, Maria, Mina, Saharias, Saora (Sawara), Pao, Pardhan, Pardhi, Paroja, Nagesia, Oraon.

Arunachal Pradesh: Abor (Adi), Aka (Hrusso), Apatani, Bagung, Bangni, Deuri, Digaru-Mishmi, Hill-miri, Idu- Mishmi, Kangbo, Khampti, Meyer, Miji, Miju, Mishing, Mishmi, Monpa, Na, Nishi, Nocte, Sherdukpen, Simpha, Sulung, Tagin, Tangsa, Tangkhul, Wanehu, Yabin.

Himachal Pradesh: Bhat, Gaddi (Gadi), Johari, Kanaura.

Uttar Pradesh: Dusadh, Bhoxa (Bhoksa), Kol, Bhil, Kharwal, Tharu (Tippera), Bhotia, etc.

Gujarat: Chaudhri (Chandhra), Ravalia, Damor, Dhodia, Dubla, Gamit, Kathodia, Katkuri, Kokna, Kunbi, Paradhi, Patelia, Rathawa, Vasavas.

Bihar: Asur, Bathudi, Bedia (Beria), Birhor, Gond, HO, Karmali, Kharia, Kherwar, Kora, Kurmi, Santhal, Sauriya Pahariya.

Jharkhand: Baiga, Korwa, Lohra, Munda, Mahto, Mallar, Parhaya, Porja, Sauria Pahariya.

Chhatisgarh: Kol (Munda), Majhi, Majhwar, Muria, Gond, Nagesia, Pao, Abujhmaria.

Jammu & Kashmir: Amchi (Laddakh), Bakarwala (Gujjars), Gujjar.

Karnataka: Badaga (Nilgiri Hills), Koli (Dhor-Koli), Koya, Marati, Mullukurumban, Wynaadan-chetty, Yerava.

Kerala: Panyan, Pathiyar, Pulayan, Uridavan-Gowdatu, Adiyan, Hill Pulaya, Ilava, Irula, Kadai, Kanikkar, Karimpalan, Kundu Vadian, Kurichya (Kurichchan), Kuruman, Kurumba, Malaarayan, Malakkaran, Malapantaram, Malavettivam, Malayar, Muthuvan.

Maharashtra: Bhil, Dhanka, Dhanwar, Dhodia, Dubla, Halba (Holwa), Kokna, Kolam, Kolimahadev, Koli Malhar, Korku, Maria, Pardhan, Pardhi, Pathawa, Thakur, Varii.

Orissa: Bagata, Banjara, Bathudi, Bhatra, Bhuiya, Bhumia, Bhumij, Binjhal, Buijhwar, Gadaba, Gondaru, HO, Juang, Kharia, Kharivar, Kisan (Kuda), Kol, Kolha, Konda, Dhora, Kora, Koya Lodha, Mallar, Mirdha, Munda, Mundari, Porja Santal Sounti.

Rajasthan: Bhil, Garasia, Kathodia, Katkari, Mina, Saharias.

Tamil Nadu: Irula, Kadar, Kota, Kuruman, Kurumla, Malasar, Malayali, Mullukurumban, Panyan, Toda, Urali, Kurumba.

West Bengal: Asur, Bathudi, Bhotia, Bhumij, Bishor, Chick Barak, Ho (Munda), Kharwar, Kora, Korwa, Lepcha, Lodha, Lohra, Mahali (Mahli), Male (Maler), Parhaya, Santhals, Sheipa, Toto.

Assam: Bodo or Boro-Kachari, Chakma, Deori, Dimasa-Kachari, Garo, Hojong, Hmar, Hojai, Kachari including Sonwal, Khasi and Jaintia, Kuki, Barmons, Lalung (Bodorace), Mech, Mikir (Karbi) Mishings, Hill miris.

Manipur: Amol, Anal, Angami, Chira, Chothe, Gangte, Hmar, Kubui, Kacha Naga, Koirao, Koireng, Kom, Lamgang, Mao, Maram, Maring, Mizo, Monsang, Moyon, Paite, Purum, Ralte, Sabte' Sema, Simte, Tangkhul, Thodou, Vaiphei and Zou.

Meghalaya: The Garo, Khasi and Jaintia, Banai, Baro, Bhoi, Biate, Dalu, Hajong, Koch, Lyngam, Man, Rabha and War Jaintia.

Mizoram: Miza (Hmar, Lushai, Paite, Pawi, Ralti), Lakheri, Kuki, Thode, Chakma, Chowngthu, Abzia (Mora), (Chawhto, Nagenta, Khanlthting, Khaingte, Pautu, Rawite, Renthlet, Tlau, Vongachhia, Zawngte).

Nagaland: Nagas (16 scheduled tribes) including Angami, AO, Chakhesang, Chang, Chirr, Konyak, Khei, Mnungan, Lotha, Makware, Phom, Rengma, Sangtam, Sema, Tikhir, Yimchungrel, Zeliang'

Sikkim: Bhotia and Lepcha.

Andman & Nicobar Island: Andmanese, a small tribe of Negrito race of a few dozen persons, Jarawa (Jorawa), Nicobarese, Onge Sentinelese, Shompen (Great Nicobar).

6.5 IMPORTANCE OF ETHANOBOTANY

The Significance of ethanobotany is manifold. Since humans came into existence we have been using plants as medicines and food. Ethanobotanist study how people in different areas and different cultures have used plants throughout history. This area of study has become more popular as people around the world have become more interested in the medicinal qualities of plants. Beginning in the twentieth century, the field of ethanobotany experienced a shift from the raw compilation of data to a greater methodological and conceptual reorientation. The study of indigenous food production and local medicinal knowledge may have practical implications for developing sustainable agriculture and discovering new medicines. Ethanobotany also encourages an awareness of the link between biodiversity and cultural diversity, as well as a sophisticated understanding of the mutual influences (both destructive and beneficial) of plants and humans. Ethanobotany, in totality, is virtually a new field of research, and if this field is investigated thoroughly and systematically, it will yield results of great value to the ethanologists, archaeologists, anthropologist, plant-geographers and pharmacologists etc. The knowledge of ethanobotany plays a vital role in the primary health care and economy of the tribals and aboriginal populations of our country and has potential for the discovery of new herbal drugs and new sources of nutraceuticals etc. The agricultural practices are not technologically advanced and most tribal groups in north-east part of India resort to shifting cultivation widely known as Jhum. Jhuming or shifting cultivation involves felling of forest trees, clearing of shrubs and undergrowth in limited area and turning of soil for sowing crops. Ethanobotany contributes to an understanding of agriculture in two ways:

1-By explaining and describing the many different ways the same crop can be raised, whether for economic gain, a desire for sustained yield, or other culturally specific purposes.

2-By revealing ways to create genetically altered plants are almost the exclusive source of drugs for the majority of World population even today. Plant products constitute approximately 25% of the total prescribed medicines even in developed countries like U.S.A. Use of plants in folk medicine is very Prevalent in Central India (Jain, 1963, Jain and Tarafder, 1963). The record of use of herbal medicines in India is very ancient. India with diverse ethnic groups and rich biodiversity has a century old heritage of medicinal phototherapy for the treatment of various diseases and promotion of health.

The Botanists collects the information regarding the traditional uses of many plant species which are unknown to modern society from tribals. Anthropologists have to deal with the cultural aspects of the life of tribal people.

The ethno botanical studies throw light on certain unknown useful plants and new uses of many known plants which can be exploited for developing new sources for some plant products and agro based industries such as, food processing, fibres and floss, cordage and basketry, extraction of edible and non edible oils, gum, resins, tannin, dye extraction for the upliftment of tribal communities.

The study of ethno botany provides valuable information to the scientists, planners and administrators for the preparation of action plan for the economic emancipation of tribals and Eco development of tribal areas.

6.6 ETHNOBOTANY AND CONSERVATION OF NATURAL RESOURCES

The importance of Ethanobotany is that it has an important role to play in conservation of nature and culture, and in particular, the biological diversity and the diversity of traditional human cultures. Indigenous knowledge of food and medicinal plants can add value in the overall conservation and sustainable management of natural habitats and ecosystem. The indigenous knowledge which is transmitted from their ancestors is being well maintained as guarded secret. Local knowledge provides new insights and opportunities for sustainable and multipurpose use of resources and offers contemporary strategies for preserving cultural and ecological diversity. In recent years conservationists have realized that the maintenance of protected areas is closely linked to rural development. Indigenous people (particularly those that depend on forests) regularly face the threat of biodiversity loss, a factor that may affect their quality of life due to land degradation and deforestation. It is important that local indigenous peoples be given opportunity to conserve their own culture. Local people should be part of a conservation programme. *In-situ, ex-situ*, cryopreservation etc are discussed below-

1-In situ conservation: The conservation of genetic resources through their maintenance within natural or even human made ecosystems, in which they occur, is called in-situ conservation. It is the process of protecting an endangered plant or animal species in its natural habitat. This method preserves both the population and the evolutionary process that enable the population to adapt by managing organisms in their normal state or within their normal range. For example, large ecosystems may be left intact as protected reserve areas with minimal intrusion or alteration by humans. In India, ecologically unique and biodiversity-rich regions are legally protected as biosphere reserves, national parks, Sanctuaries, nature reserves, reserved forests. India now has 14 biosphere reserves, 90 national parks and 448 wildlife sanctuaries.

2- Ex-situ conservation is the conservation of plants away from their areas of natural occurrence. The knowledge of ethanobotany is important to manage plants in the landscape for better watershed management. For watershed development and management, the contribution of local people’s knowledge, consortium approach and adoption of new technology are important to achieve desired result for insuring sustainable utilization of natural resources in a given watershed. The watershed approach enables planners to harmonize the use of soil, water and vegetation in a way that conserves these resources and maximize their productivity. The impact of resource conservation in a Shivalik micro watershed was studied 10 years after imposition of protection. The main activity taken up in the micro watershed was the construction of an earth fill dam in 1992 at the outlet to runoff water from a contributing area of 59.6 ha consisting of sparse vegetation. Ex-situ conservation and maintenance of samples of living organisms outside their natural habitat, in the form of whole plants, seed, pollen, vegetative propagules, tissue or cell cultures. This involves conservation of genetic resources, as well as wild and cultivated or species, and draws on a diverse body of techniques and facilities. Botanical gardens play a key role in ex-situ conservation of medicinal plants. In India, we have a network of 140 botanical gardens which includes 33 botanic gardens attached to the Universities. Some of these are meant for medicinal plants and there are exclusive herbal gardens (National Botanic Gardens, now NBRA- National Botanical Research Institute) at Lucknow and Tropical Botanic Garden and Research Institute at Palode (TBGRI- near Tiruvananthapuram) have medicinal plants wings.

Ex-situ conservation provides excellent research opportunities on the components of biological diversity.

3-Cryopreservation is the process of freezing biological material at extreme temperatures; most common-196^{0}C / -321^{0}F in liquid nitrogen (N_2). The objective of cryopreservation is to minimize damage to biological materials, including tissues, mammalian cells, bacteria, fungi, plant cells, and viruses, during low temperature freezing and storage. Cryopreservation technology is important to preserve the genetic diversity of a particular plant or genetic stock for its use at any time in future.

In India, 4.5 % of total geographical area constitutes protected area network, comprising eight designated biospheres, 87 national parks, and 447 wildlife sanctuaries. These protected areas harbour large varieties of medicinal plants.

The Himalayan region is blessed with an immense amount of natural resources such as forest, water and wildlife. The local inhabitants have been dependent upon indigenous plant resources for their daily needs. The people of the Himalayan region are well aware of valuable species of medicinal and aromatic plants. These are now under stress due to over-extraction. Conservation of these valuable resources is now crucial. The wise use, development and conservation of our natural resources is every individuals duty.

6.7 PLANTS OF ETHNOBOTANICAL IMPORTANCE

India has about 563 tribal communities having past traditional knowledge through their long association with the forests. They have collected valuable knowledge on the use of wild plants in their daily life for food, fuel, fodder, clothing, health-care and other purposes. Many native people also use plants in ceremonial or spiritual rituals. Most of the traditional knowledge about plants and their uses in fast disappearing as a consequence of socio-economic and land use changes. The ethnobotanical studies through light on certain unknown useful plants and new uses of many known plants which can be exploited for developing new sources for some plant products and agro based industries. Botanical Survey of India initiated recording and documenting this ethnobotanical data of all tribes belonging to the states of Bihar, Goa, Karnataka, Orissa, Rajasthan, Himachal Pradesh, Chattisgarh, Uttarakhand, Andaman and Nicobar Islands, Andhra Pradesh, Arunachal Pradesh, Assam, Jammu and Kashmir, Madhya Pradesh, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh and West Bengal for critical studies leading to sustainable utilisation of bioresources, documentations of traditional knowledge system.

The tribals and natural populations living in different parts of India use plant species of forest floras for food, fodder, fibres house building, fuels, medicines, beverages, oils, gums, resins, dyes, basketry, timber and wood works, musical instruments, fish poisons, religious ceremonies, narcotics etc. About 5000 plant species have been recorded so far which are used by tribals and aboriginal communities in different states.

Food plants of tribal people

Indigenous people are those who retain knowledge of the land and food resources rooted in historical continuity within their region. The food systems of Indigenous people often included “traditional foods”, that is, which indigenous people have access to locally, without having to purchase them, and within traditional knowledge and the natural environment from farming or wild harvesting. Tribals take shelter from forest and utilize wild edible plants both raw and cooked. Forest plays an important role in enhancing livelihood requirements for rural community. Over 50 million tribal people in India belong to 550 communities of 227 ethnic groups (1-3) and about 60 % of the rural communities directly rely on forest for their day-to-day requirement. The flower and fruits are generally eaten raw where as tubers, seeds and leaves are cooked. There is an enormously larger number of plants that are potentially edible (about 30,000 species), including about 7,000 species that are being utilized locally by indigenous peoples as nutritious sources of food.

Tribal people through their hereditary traditional knowledge know about the useful and harmful effects of plant food. The foods, habits of people are developed on the basis of experience and survival through successive generations.

Earliest food gathering man gathered fruit, nuts, moss, tubers, mushroom, morels and stems in season. Now they are fully aware how to exclude the substances from the wild plants and preparing recipes for their meager meals. A list of some wild plants used as food is given below:

1- *Annona squamosa* Verna. Sharifa, family- Annonaceae. The fresh flowers are eaten, the ripe fruits are eaten and the under-ripe fruits are roasted and eaten.

2- *Bauhinia purpurea*, *B.variegata* and *B.diffusa,* Verna, Kachnar, Family- Caesalpiniaceae. The tender leaves, buds and flowers are eaten as vegetable.

3-*Bombax ceiba,* verna. Semal, Family-Bombacaceae. The flowers and young fruits are eaten as vegetable.

4- *Cassia fistula*. Verna. Amaltas, Family-Caesalpiniaceae. The flower buds and the flowers are used as vegetable by tribals.

5- *Emblica officinalis*. Verna. Amla. Family- Euphorbiaceae. The fruits are eaten raw or cooked.

6- *Ficus religiosa.* Verna. Peepal, family- Moraceae. The leaf buds are used as vegetable.

7- *Holostemnia annulare.* Verna. Dudhi, family- Asclepiadaceae. The leaves are used with pulses to make curry.

8- *Indigofera pulchella*, Verna. Jirhul, family- papilionaceae. The pink flowers are eaten as vegetable.

9- *Leucas cephalotes*, Verna. Durup, family-Lamiaceae. The leaves are used as vegetable.

10- *Madhuca latifolia,* Verna. Mahua, family-Sapotaceae. The flowers are eaten fresh and dry. The fruits are eaten as vegetable. A spirit prepared from flowers is considered as tonic and nutritive.

11- *Moringa oleifera.* Verna. Sainjana, Family- Moringaceae. The pods and flowers are used as vegetable.

12- *Randia dumetorum*. Verna. Maurea, Family- Rubiaceae. The leaves are used as vegetable, and the ripe seeds are edible.

13- *Shorea robusta,* Verna. Sal, Sakna, Sarjan, Daru, Family-Dipterocarpaceae. The seeds are eaten by the poor as a famine food.

14- *Terminalia cremulate.* Verna-Asan, Family- Combretaceae. The hard gumming exudates from the stem is called 'asan-latha' is eaten and considered delicious.

15- *Dioscorea bulbifera.* Verna- Gethi kanda. The yam is cut into slices, boiled and kept in running water and eaten.

Some less known ethnic plants which are used by tribals for food, ethno medicine and narcotic purposes are listed here.

Plant Species	**Common Name**	**Family**	**Plant parts used**	**Tribal areas**
Vegetables				
Amaranthus spinosus	Kanta chaulai	Amaranthaceae	Young shoots	
Amaranthus viridis	Jangali Chaulai	Amaranthaceae	Young shoots	
Aspragus racemosus	Shatavari, or Shatamull	Liliaceae	Tuberous roots and tender shoots	North Bengal
Bambusa khasiana		Poaceae	Young shoots	Meghalaya & Manipur

Bambusa tulda	Jati	Poaceae	Young shoots	Meghalaya & Manipur
Bambusa vulgaris	Baans	Poaceae	Young shoots	Meghalaya & Manipur
Bauhinia purpurea	Kaniar	Caesalpiniaceae	Flower buds	Sikkim, Darjeeling
Begonia palmata	Begonia	Caesalpiniaceae	Tender shoots and leaves	N-E India
Boerhaavia diffusa	Punurnava	Nyctaginaceae	Leaves	
Bombax ceiba	Simal	Bombacaceae	Flwer buds and fleshy calyx	Assam, Manipur, Meghalaya
Buddleja asiatica	Neemda, Dhaula	Loganiaceae	Leaves (eaten raw)	Arunachal Pradesh
Calamus erectus and *C.tenuis*	Jeng bet (in Assam)	Arecaceae	Young shoots	Arunachal Pradesh, Assam
Chenopodium album	Bathua	Chenopodiaceae	Young shoot India	N-E India, Central
Chlorophytum arundinaceum	Safed musli	Liliaceae	Whole plant	N-E India
Clerodendron spp		Verbenaceae	Tender shoot & leaves	N-E India
Colocasia esculenta	Arvi	Araceae	Tender leaves & corm	All over India
Commelina bengalensis	Kana	Commelinaceae	Young leaves	N-E India
Costus spaciosus	keukand	Zingiberaceae	Flowers and rhizome	Sikkim, Manipur
Cyathea gigantean (Tree fern)		Cyathiaceae	Pith	Nishi & Shulung of Arunachal Pradesh
Debregeasia longifolia	tusara, sausaru	Urticaceae	leaves	Uttarakhand
Dioscoria spp.	Yam	Dioscoriaceae	Tubers and Bulbils	Uttarakhand
Diplazium esculentum		Athyriaceae (fern)	Young fronds	N.E. India
Elatostema platiphyllum		Urticaceae	leaves	Assam, Arunanchal States

Fagopyrum dibotrys (Syn. F.cymosum	Ban ogal	Polygonaceae	leaves	N.E.India, Uttarakhand, J&K, Shimla
Fagopyrum esculentum	Kuktu	Polygonaceae	Leaves and seeds	N.E.India, Uttarakhand, J&K, Shimla
Girardinia palmate		Urticaceae	Tender shoots	Sikkim, Darjeeling
Ipomoea aquatic	Nali	Convolvulaceae	Tender shoots	N.E.India, Uttarakhand, U.P., M.P., Bihar
Lassia spinosa	Invider kand	Araceae	rhizomes	Assam, Nagaland
Meliosma pinnata		Salriaceae	Young leaves & shoots	Napalese in Sikkim
Moringa oleifera	Senjana	Moringaceae	Young leaves and fruits	All tribals in India use it Sikkim, Assam
Musa balbisiana	Banana	Musaceae	Young fruits and inforescence	Sikkim, Assam, Darjeeling
Natsiatum herpeticum		Icacinaceae	Leaves & young shoots	Sikkim, Assam, Darjeeling
Oenothera javanica		Apiaceae	Young shoots	Sikkim, Arunachal
Plantago erosa (Syn. P. major)	Lahuriya	Plantaginaceae	Tender shoots	Arunachal, Manipur
Portulaca oleracea	Lunia	Portulacaceae	Leaves & shoots	All over India
Pueraria tuberose	Vidarikand	Fabaceae	Tubers & young shoots	Sikkim
Rhus javanicus	Tatri	Anacardiaceae	Tender shoots	Sikkim, Darjeeling, Manipur
Rumex hastatus	Amlora, Chulmora	Polygonaceae	leaves	N.E. India, Bihar, U.P., Uttarakhand
Solanum indicum	Badikateri, Jangli bhata	Solanaceae	Fruits	N.E. India
Sterculia indica		Sterculiaceae	Tender shoots	N.E. India
Urtica ardens	Himalayan Nettle (in English)	Urticaceae	Young leaves & shoots	Sikkim, Manipur
Vaccinum		Vacciniaceae	Leaves & flower	Manipur, Sikkim

vacciniaceum				
Zanthoxylum acanthopodium	Darmar, tejphal	Rubiaceae	Tender shoots & leaves	Manipur, Meghalaya, Manipur, Arunachal Pradesh
Fruit and Seeds				
Aegle marmelos	Bael	Rutaceae	Pulp of ripe fruits	N.E. India, Bihar, U.P., Uttarakhand, M.P., Orissa, Bihar
Aglaia edulis		Meliaceae	Aril	Sikkim, Darjeeling
Ampelocissus barbata	Jarila-lahari	Vitaceae	Ripe fruits	Sikkim, Manipur
Aporusa octandra		Euphorbiaceae	Ripe fruits	Sikkim, Manipur, Arunachal, Meghalaya
Artocarpus chama	Chaplasp	Moraceae	Ripe fruits	N.E. India, U.P., Bihar, Uttarakhand
Bauhinia purpurea	Kaniar	Caesalpinaceae	Seeds	Sikkim, Darjeeling
Castanopsis indica	Chestnut, Hinguri	Fagaceae	Fruits and seeds	Assam, Meghalaya
Clausena dentata		Rutaceae	Ripe fruits	Sikkim
Daphiniphyllum himalayense		Daphniphyllaceae	Ripe fruits	Arunachal Pradesh
Dandrocalamus hamiltonii	Kaghsi bans	Poaceae	Seeds used as rice	Arunachal, Assam, Sikkim, Darjeeling
Duchesnea indica (Syn. Fragaria indica)	Kiphaliya	Rosaceae	Fruits	Khasia, Manipur, Arunachal
Echinochloa coloum	Jungle rice	Poaceae	Grains	Arunachal, Mehgalaya
Elaeagnus caudate	Wild Olive	Elaeagnaceae	Ripe fruits	N-E.India
Elaeagnus pyriformis		Elaeagnaceae	Ripe fruits	N-E.India
Emblica officinalis	Amla	Euphorbiaceae	Fruits	N-E.India, U.P., Bihar, M.P.
Evodia fraxinifolia		Rutaceae	fruits	Sikkim, Manipur

Fagopyrum esculentum	Kotu, kuktu	Polygonaceae	seeds	N-E.India
Fagopyrum dibotrys	Ban ogal	Polygonaceae	Made into flour	Uttarakhand
Ficus hispida	gobla, kagsha	Moraceae	Ripe fruits	Sikkim, Manipur, Assam
Garcinia anomala		Clusiaceae	fruits	Manipur
Garcinia pedumeulata	Amalvet	Clusiaceae	fruits	Assam, Manipur
Gnetum gnemon		Gnetaceae	Seeds	Assam, Manipur
Hodgsonia macrocarpa	Lard fruit	Cucurbitaceae	Roasted seeds	N-E.India
Knema lincifolia		Myristicaceae	fruits	Manipur, Meghalaya
Litsea cubeba	Mountain Pepper	Lauraceae	fruits	Sikkim, Darjeeling
Mangifera sylvatica	Himalayan Mango, Pickling Mango	Anacardiaceae	fruits	Sikkim, Darjeeling
Melia dubia	Malabar Neem, kadukhajur	Meliaceae	fruits	Sikkim, Darjeeling
Microcos paniculata	Shiral	Teliaceae	fruits	Manipur, Maghalaya, Uttarakhand
Morus australis	Contorted mulberry	Moraceae	fruits	N-E.India, Uttarakhand
Musa balbisiana(Syn. M.sikkimensis)	Bhimkol	Musaceae	fruits	Sikkim, Darjeeling
Myrica esculenta	kaphal	Myricaceae	fruits	Sikkim, Darjeeling
Phoenix acaulis	Chota khajur	Aracaceae	Ripe fruits	Sikkim
Prunus cerasoides	Padam	Rosaceae	Ripe fruits	Arunachal, Manipur, Uttarakhand, H.P.
Pyrus pashia	Mehal Mole, Kainath	Rosaceae	fruits	Meghalaya, Manipur
Rhus javanica	Tatri	Anacardiaceae	Fruits	Sikkim, Darjeeling,

				Manipur
Rubus biflorus		Rosaceae	Fruits	Sikkim, Manipur
Rubus ellipticus	Lalanchu, Hinsal	Rosaceae	fruits	Sikkim, Manipur
Saurauria nepalensis		Saurauriaceae	Fruits	Arunachal, Sikkim, Meghalaya
Sterculia villosa	Katira	Sterculiaceae	Roasted seeds	N-E.India
Syzygium claviflorum	Grey Satinash	Myrtaceae	Ripe fruits	Sikkim, Darjeeling
Tetrastigma bracteolatum		Vitaceae	Ripe fruits	Sikkim, Manipur
Viburmum cotinifolium		Caprifoliaceae	Ripe fruits	Sikkim
Zizyphus apetata		Rhamnaceae	Ripe fruits	Sikkim
Ethnomedicinal plants				
Acorus calamus	Bach	Araceae	Root and rhizome paste used as antiseptic, paste is used in snake bite, Leprosy	Tharu in Kheri district Nagaland, Arunachal, Sikkim
Aconitum ferox	Bachang, Meetha vish	Ranunculaceae	Corm and root powder is given to animals to cure sickness	Nagaland, Arunachal
Alpinia galanga	bara-kulanjan	Zingiberaceae	Rhizome powder is given orally for rheumatism, piles and respiratory troubles in children	Manipur Nagaland, Arunachal
Amomum aromaticum	Morang ilachi	Zingiberaceae	Paste of rhizome and seed given for abortion and as purgative	Arunachal, Meghalaya
Begonia palmata		Begoniaceae	Plant extract is cure for stomach ache and	Nagaland

			diarrhoea	
Berginia ciliata	Pashanbheda	Saxifragaceae	Plant extract is cures cough and cold, paste of plant stops bleeding	Arunachal, Sikkim
Clerodendron colebrookianum		Verbenaceae	Leaf paste is applied in rheumatism and gout, plant decoction is a cure for Malaria	Assam, Nagaland
Coptis teeta	mameera	Ranunculaceae	Plant decoction is used in cough, cold and fever, backache and Malaria	Arunachal
Costus speciosus	Keukand, Keu, Kust	Zingiberaceae	Rhizome decoction given in kidney stone, burning pain during urination	Nagaland, Manipur
Croton roxburghii	Bhutala	Euphorbiaceae	Seeds are purgative, seed oil is insecticide, plant juice is antidote to snake poison	Nagaland, Manipur, Arunachal
Curcuma angustifolia	Tikhur	Zingiberaceae	Rhoizome juice is rubbed on swollen parts and paste applied on bone fracture	Nagaland
Eclipta prostrata	Bhringaraj	Asteraceae	Aqueous extract of plant given in body swelling	Tharus of U.P.
Eryngium foetidum	Ban dhania	Apiaceae	Plant juice is used for headache, fever and as tonic	Nagaland
Euphorbia		Euphorbiaceae	Paste of root	Tharus of U.P.

acaulis			stock boiled with linseed oil is applied on rheumatism	
Geranium nepalense	ratanjot	Geraniaceae	Powder of whole plant is given in stomach disorders	Nagaland, Sikkim, Darjeeling
Helictres isora (Vsn. Marorphali)	Maror phali	Sterculiaceae	Seed extract is given in dysentery	Tharu of U.P.
Hedychium spp.		Zingiberaceae	Decoction of rhizome is cure for bronchitis, tonsillitis, throat and stomach trouble	Arunachal, Manipur
Hydnocarpus kurzii		Flacourtiaceae	Seed oil is a cure for leprosy	Nagaland, Manipur
Helminthostachys zeylanica	Kamraj	Ophioglossaceae	Rhizome decoction is given in impotency and leaf juice cures tongue blisters	U.P.(Tharu)
Picrorhiza kurroa (Kutki)	Kutki	Scrophulariaceae	Root decoction is given in diarrhoea, cough, influenza, fever. It is effective in liver and spleen disorders	Arunachal, Sikkim, Dharchula in Pithoragarh (Uttarakhand)
Piper spp.		Piperaceae	Paste of stem and black pepper is given for sterilization of woman, and leaf juice cures eye troubles	Assam, Darjeeling, Sikkim, Meghalaya
Podophyllum hexandrum		Podophyllaceae	Decoction of roots and rhizome is given for tumor	Arunachal

			and skin diseases and as purgative	
Rubia cardifolia	Majith	Rubiaceae	Root and stem decoction is given for stomach ailment, chest trouble, jaundice and irregular menstruation and cancer	Meghalaya, Darjeeling, Nagaland, Pithoragarh (Uttarakhand)
Solanum viarum		Solanaceae	Seed powder mixed with mustard oil is inhaled to relieve headache, cold, blocked nose and insanity	Assam, Meghalaya, Nagaland, U.P. (by Tharu)
Solanum torvum	Bhurat, Bhankatiya	Solanaceae	Leaf decoction is given in snake bite, and fruits given in cough and tonsil complaints	Khasi, Jantia, Manipur
Stephania glabra	Rajapatha, Gindaru, Ganeeth	Manispermaceae	Tuber powder along with honey is given in Asthma and stomach tumor. Juice of tuber is dropped in eyes to cure eye diseases	Nagaland
Swertia chirayeta	Chirayata	Gentianaceae	Plant powder is given in stomache and root decoction in fever and influenza	Nagaland, Sikkim, Uttarakhand
Taraxacum officinalis	Dudhi, Baran	Asteraceae	Given in malaria and urinary complaints	Arunachal

6.8 AREAS OF ETHANOBOTANICAL STUDIES

Ethnobotanists engage in a broad array of research questions and practices, which do not lend themselves to easy categorization. However, the following headings attempt to describe some of the key areas of modern ethnobotanical study.

1-Archaeoethnobotany: Archaeoethnobotany involves three subjects namely, archaeology, ethnology, and botany. This interdiscipline of ethanobotany studies the identification of plant materials from archaeological sites for studies on migration of human cultures, and origin, dispersal and domestication of crops, etc, (Smith J., 1965).

2- Ethnoecology: Ethnoecology is the scientific study of the past and present interrelationships between human societies, and their living and non-living environment. It seeks valid, reliable understanding of how humans have interacted with the environment and how these intricate relationships have been sustained over time.

3- Ethnomedicine: includes research that deals with medicines derived from plants, animals, minerals, etc., and used in the treatment of various diseases and ailments, based on indigenous phurmacopoeia, folklore and herbal charms (Weiner, 1971). Ethnomedicine is a sub-field of medical anthropology that deals with the study of traditional medicines—not only those with relevant written sources (e.g., Traditional Chinese Medicine and Ayurveda), but also those whose knowledge and practices have been orally transmitted over the centuries.

4- Ethnogynaecology: is an emerging discipline that deals with various diseases among women in tribal societies, related to sterility, conception, abortion, etc., and the use of abortifacients (Tarafder, 1983).

5- Ethnomusicology: is defined as "the study and cultural aspects of music and dance in local and global contexts". It also includes the study of musical instruments they make and use, which are often made of plant materials.

6- Ethnomycology: is the study of mushrooms and other fungi by common people, as food or medicine, or in crafts, stories, or rituals.

7-Ethnonarcotics: deals with study of the use of narcotics, snuffs, hallucinogens, etc, in primitive human societies.

8-Ethnopharmacology: is the scientific study correlating ethnic groups, their health, and how it relates to their physical habits and methodology n creating and using medicines. This is a key field that often explains the effectiveness of herbal medicine, stimulants, analgesics, inebriants or psychoactive species. Both ethnomedicine and ethnopharmacology overlap significantly with ethnobotany.

9-Ethnotaxonomy: The term ethnobotany refers the naming and classification of plants and their cultivars, and animals and their races by human societies in their language. Ethnotaxonomy studies the ethnic concepts of classification of plants based on habit, habitat, colour, odour, usage or some other parameters.

10-Ethnotoxicology: Study of use of various plants as fish poison (Ichthyotoxic), arrow poisons etc., in human societies. The adivasis possess immense knowledge on procurement of wild food using poisonous crude drugs.

11- Paleoethnobotany: deals with the identification of fossolized plant materials and remains for studies on ancient plant economy, palaeoethnobotanical history of crops and changing patterns. On the use of plant life by human culture (Stewart, 1976). Major research themes are recovery and identification of plant remains, the use of wild plants, the origins of agriculture and domestication, and the co-evolution of human-plant interactions.

6.9 NARCOTIC PLANTS

The term "narcotic," derived from the Greek word for stupor, originally referred to a variety of substances that dulled the senses and relieved pain. Term originally applied to all compounds that produce insensibility to external stimuli through depression of the central nervous system, but now applied primarily to the drugs known as opiates—compounds extracted from the opium poppy and their chemical derivatives. Also classed as narcotics are the opioids, chemical compounds that are wholly synthesized, but which resemble the opiates in their actions.

Many narcotic plants contain substances that have medicinal properties and are used primarily as pain relievers. Alkaloids are the principal active constituents of narcotic plants. Many of these plants are highly toxic, and the drugs obtained from them cause narcomania when frequently used.

Narcotics have a high potential for abuse. As abused drugs they are sniffed, smoked, or self-administered by the more direct routes of subcutaneous (“skin-popping”) and intravenous (“mainlining”) injection. Drug effects depend heavily on the dose, route of administration, and previous exposure to the drug. Aside from their medical use, narcotics produce a general sense of well-being by reducing tension, anxiety, and aggression. These effects are helpful in a therapeutic setting but contribute to their abuse

The uses of narcotics, snuffs, hallucinogens, etc, in primitive human societies have been noticed since the beginning of recorded history. There are such types of plant given below-

1-**Betel palm** (*Areca catechu* L.) is a tree like plants in the genus Areca and family Palmaceae. The betel palm is cultivated for its seeds, which together with lime get wrapped in betel leaves, used by natives for chewing (the mixture is called “moma”). Betel is the fourth most common psychoactive drug in the World, following caffeine, alcohol and nicotine. The seeds contain alkaloids such as arecaidine and arecoline, which when chewed, are intoxicating and slightly addictive. Areca palms are grown in India, Indonesia, Bangladesh, Taiwan, Malaysia and many other Asian countries for their seeds**.** Betel chewing releases a number of addictive alkaloids that cause sensations of mild euphoria, and regular users often have red-stained teeth and lips. In Ayurvedic medicine betel nut is used as a diuretic, digestive, anthelmintic, astringent, and cardiotonic. Betel nuts are also used as an offering to Hindu deities. Excessive use of this plant causes profuse salivation, vomiting and stupor. Betel chewing can also cause a number of serious health problems, including oral and esophageal cancer.

2-Jimson weed (*Datura* L.) is an annual with unpleasant smell, reaching up to 50 cm in height. The species belongs to the genus Datura, family Solanaceae. It is a large herbaceous, rarely arborescent plant. The seeds represent a thorned many-seeded capsule, the size of walnut. The plant contains chemicals such as atropine, hyoscyamine, and scopolamine. These chemicals interfere with one of the chemical messengers (acetylcholine) in the brain and nerves. Due to its easy availability and strong anticholinergic properties, teens are using jimson weed as a drug. Despite serious safety concerns, jimson weed is used to treat asthma, flu (influenza), cough, swine flu, and nerve diseases.

3-**Hemp** (*Cannabis* L.) is a genus of bast-fiber annuals of the family Cannabaceae. Cannabis contains psychoactive substances, cannabinoids, including tetrahydrocannabidinol (THC); it is used as raw material for popular psychotropic substances (hashish, marijuana etc). According to the modern classification, genus Cannabis includes one species with two subspecies: *Cannabis sativa* subsp. *sativa* — Common hemp, *Cannabis sativa* subsp. *indica* — Indian hemp. There was a third species earlier, called Ruderal hemp, but now it doesn't have an independent rank and considered to be a synonym of Cannabis sativa subsp. sativa. Hemp is used to make a variety of commercial and Industrial products including rope, clothes, food, textiles, paper, plastics, insulation and biofuel. Known for its characteristic leaves, the plant is used in religious practices in India.

4-**Poppy** (*Papaver* L.): A poppy is a flowering plant in the subfamily Papaveroideae of the family Papaveraceae. One species of poppy, *papaver somniferum,* is the source of the crude drug opium which contains powerful medicinal alkaloids such as morphine and has been used since ancient time as an analgesic and narcotic medicinal and recreational drug. Poppies are herbaceous plants, often grown for their colorful flowers. The seeds of the poppy are widely used as the popular "Poppy-seed" found in and on many food items such as cakes, bagles, muffins. Poppy extracts have traditionally been used to relax smooth muscle tone, making them potentially useful in the treatment of diarrhea and abdominal cramping.

5-Tobacco- *Nicotiana tobacum,* tobacco, is a stout herbaceous plant in the Solanaceae (nightshade family) that originated in the tropical America (South America, Mexico and the West Indies) and now cultivated worldwide as the Primary commercial source of tobacco. Tobacco contains the alkaloid nicotine, which is a stimulant, and harmala alkaloids. Dries tobacco leaves are mainly used for smoking in cigarettes, cigars. They can also be consumed as chewing, tobacco, snuff, dipping tobacco and snus. Tobacco causes cardiovascular diseases and lung disease.

6- Ephedra: Ephedra is a genus of gymnosperm shrubs, the only genus in its family, Ephedraceae and order, Ephedrales. The various species of Ephedra are widespread in many lands, native to Southwestern North America, Southern Europe, Northern Africa, Southwest and Central Asia, Northern China and Western South America. The whole *Ephedra sinica* plant has traditionally been used by indigenous people for a variety of medicinal purposes, including treatment of bronchial asthma, hay fever, colds, allergies, influenza, and hives in teas of tinctures. Dosages of Ephedra more than 32 mg/day have resulted in adverse reactions. Ephedra can cause a quickened heartbeat and elevated blood pressure. Side effects include heart palpitations, nausea and vomiting.

7-Sarpgandha: *Rauwolfia serpentine* (sarpagandha) also known as Black snakeroot or Indian snakeroot or devil pepper, is a species of flower in the family Apocynaceae. It is native to the Indian subcontinent and East Asia (from India to Indonesia). The herb is known to cure numerous disorders due to its constituents like alkaloids, carbohydrates, flavonoids, phlobatannins, glycosides, resins, phenols, tannins, saponins and terpenes. The root of Sarpagandha is used in medicines. Its roots contain the highest amount of active substances, which are beneficial as active substances, which are beneficial as anti-anxiety, sedative, antihypertensive and relaxing effects.

8. Quinine: *Cinchona officinalis* is a medicinal plant, one of several cinchona species used for the production of quinine. Cinchona is a genus of flowering plants in the family. Rubiaceae containing at least 23 species of trees and shrubs. Quinine is an alkaloid which can reduce fever, work against malaria, pain and swelling. The bark of the cinchona family of trees contains quinine. Quinine may cause some unwanted effects such as Diarrhoea, vomiting, nausea, stomach cramps or pain.

9. Belladonna: A poisonous plant of the nightshade family, with purplish or reddish bell-shaped flowers and shiny black berries. The word belladonna is from the Italian word belladonna literally, fairlady (so called because it is said to have been used by women to dilate the pupils of the eyes and to create an artificial Pallor). Belladonna is a natural substance made from a toxic plant. Pharmacology a drug from the leaves and root of this plant, containing atropine and related alkaloids used in medicine to check secretions and spasms, to relieve pain or dizziness and as a cardiac and respiratory stimulant.

10. Aconite: Aconite is a genus of plants belonging to natural order Ranunculaceae, the Buttercup family, also known as monkshood (because of the shape of the flower), or wolfsbane (because of its use in hunting). Aconitine and other alkaloids found in aconite are highly toxic. Despite serious concerns about safety, some people takes aconite by mouth for facial paralysis, finger numbness, joint pain, gout, fever, skin diseases etc. Aconite has been used since ancient times, especially as an antidote.

6.10 SUMMARY

Ethanobotany is the systematic study of the relationships between plants and people. The term Ethanobotany was coined by J.W. Harshberger. Ethanobotanical studies involve the interaction between plants and people and the management of plant diversity by indigenous communities and the traditional use of plants. India has been the most ethnically diverse nation on earth for many centuries. Ethanobotany encourages an awareness of the link between biodiversity and cultural diversity. The study of ethanobotany provides valuable informations to the scientists, planners and administrators for the preparation of action plan for the economic emancipation of tribals and eco development of tribal areas. Ethanobotany has an important role in conservation of natural resources through in-situ, ex-situ, cryopreservation etc conservation programmes. The tribals living in different parts of India use plant species for food, fodder, fibres house building, medicines etc. Areas of Ethanobotanical studies are Archaeoethanobotany, Ethnomedicine, Palaeothanobotany etc. The use of narcotics, snuff, hallucinogens etc, in primitive human societies have been since the beginning of recorded history.

6.11 GLOSSARY

Ethanobotany: It is the study of human interaction with the plant world.

Ethanobiology: It is the study of the relationships between people, the life forms surrounding them, and the environment in which they live, in the past or present.

Ethanomycology: It is the study of folk knowledge of mushrooms and other fungi.

Ethanomedicine: It is study of traditional medicines, whether written, or remembered and transmitted via oral tradition.

Ethanopharmacology: It is the study of the uses, effects and modes of actions of naturally-occurring drug compounds.

Ethanomusicology: It is the study and cultural aspects of music and dance in local and global contexts.

Ethanoecology: It is the scientific study of the way different groups of people in different locations, understand ecosystems around them, the environments in which they live and their relationship with these.

Narcotic: anything that relieves pain or induces sleep, mental numbness, etc.

Indigenous: Existing, growing, or produced naturally in a region or country; belonging (to) as a native

Jhum cultivation: also known as the slash and burn agriculture, is the process of growing crops by first clearing the land of trees and vegetation and burning them thereafter.

Helminths: worm that is parasitic on the intestines of vertebrates especially roundworms and tapeworms and flukes

Tetrahydrocannabidinol (THC): A compound that produces psychoactive effects in humans.

6.12 SELF ASSESSMENT QUESTIONS

6.12.1 Multiple choice Questions:

1-The study of folk knowledge of mushrooms and other fungi
(a) Ethnotoxicology (b) Ethanarcotics
(c) Ethanomycology (d) Ethanomedicine

2- Which one of the following is not a narcotics plant?
(a) Hemp (b) Kutki
(c) Poppy (d) Datura

3-Botanical names of majith is
(a) *Rubia cordifolia* (b) *Picrorhiza kurroa*
(c) *Curcuma angustifolia* (d) *Ficus hispida*

4-Which one of the following ethnic group belongs to Uttarakhand -
(a) Khond (b) Johari
(c) Majhwar (d) Gangwal

5-*Aegle marmelos* belongs to family-
(a) Rubiaceae (b) Rutaceae
(c) Moraceae (d) Fabaceae

6.12.2. True or False

1- Nux-vomica is a anticancer drug.
2- Tobacco plant belongs to family Solanaceae
3-Botanical name of Amla is *Fagopyrum dibotrys.*
4-Jaunsari, the ethnic group belongs to Gujarat State.
5- Simal is the common name of *Bombax ceiba.*

6.12.1 Answer Key: 1-(c), 2-(b), 3-(a), 4-(d), 5-(b)
6.12.2 Answer Key: 1-False, 2-True, 3-False, 4-False, 5-True

6.13 REFERENCES

- Pei.S.J.1996. 'Biodiversity Resources in the Himalayan Region'. Paper presented at the International Symposium on Floristic Characteristics and Diversity of East Asia Plants, held on July 25-27, 1996 in Kunming, China

- Shukla, R.S. and Chandel, P.S. 1972, A Textbook of Plant Ecology including Ethanobotany and Soil Science, S. Chand and company Pvt. Ltd
- http://bsi.gov.in/content/263_1_EthnobotanicalStudies.aspx
- *www.biologydiscussion.com/botany/ethno-botany-definitions...importance/7158*
- *www.biologydiscussion.com/botany/ethno-botany-definitions-development.*
- *shodhganga.inflibnet.ac.in/bitstream/10603/22087/10/10_chapter%201.pdf*
- B.P.Pandey-Economic Botany, S. Chand and Publications

6.14 SUGGESTED READINGS

- Shukla, R.S. and Chandel, P.S. 1972, A Textbook of Plant Ecology including Ethanobotany and Soil Science, S. Chand and company Pvt. Ltd

6.15 TERMINAL QUESTIONS

1- Define Ethanobotany. Discuss its concept and History.
2- Describe in detail the ethnic groups of India.
3- Give a detailed note on conservation of natural resources.
4- Explain about the plants of ethanobotanical importance.
5- What are narcotic plants? Give a brief description about five narcotic plants.

BLOCK-2 BIODIVERSITY AND CONSERVATION

UNIT-7 BIODIVERSITY-BASIC CONCEPT

Contents

7.1 OBJECTIVES

After reading this unit students will be able-

- to know about the concepts of the biodiversity conservation
- acquaint with the biodiversity profile at national as well as global
- learn about the various threats to the biodiversity

7.2 INTRODUCTION

Life on Earth is diverse at many levels, beginning with genes and extending to the wealth and complexity of species, life forms, and functional roles, organized in spatial patterns from biological communities to ecosystems, regions, and beyond. The study of biodiversity encompasses the discovery, description, and analysis of the elements that underline these patterns as well as the patterns themselves. The challenge of quantifying patterns of diversity at the species level, even when the organisms are known to science, is complicated by the problem of detecting rare species and the underlying complexity of the environmental template.

The term ‘‘biodiversity’’ was first used in its long version (biological diversity) by (Lovejoy, 1980) and is most commonly used to describe the number of species.

From hot arid deserts of the Sahara, through the lush green rainforests of the Amazon, to the ocean depths and bright corals, our natural world is a marvel of different landscapes, materials, colours and textures. The land, air and seas of our planet are home to the tiniest insects and the largest animals, which make up a rich tapestry of interconnecting and interdependent forces.

Biodiversity found on Earth today consists of many millions of distinct biological species, the product of four billion years of evolution.

E. O. Wilson first used the term biodiversity in the literature in, the concept of biological diversity from which it arose had been developing since the nineteenth century and continues to be widely used.

Biodiversity encompasses the variety of life, at all levels of organization, classified both by evolutionary (phylogenetic) and ecological (functional) criteria.

The most acceptable definition of the biodiversity is the one held by the CBD which was signed by the more than 180 nations on June 5, 1992 at Rio-De-Janerio. But, there are at least 12 formal definitions. The CBD states that Biological Diversity means the variability among living organisms from all sources, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complex of which they are part, this includes diversity within species, between species and of ecosystems.

In other words Biodiversity is the variety of life in all many manifestations. It encompasses all forms, levels and combinations of natural variations.

The actual definitions as per the conventions: the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and technologies and by appropriate funding.

But another definition as per the WCMC (1992) in their edited book {Global Biodiversity} is "Diversity is a concept which refers to the range of variation or differences among some sets of entities: biological diversity thus refers to variety within the living world. Thus the term is often used to describe the number and variability of living organisms".

Several definitions framed by the different scientists from time to time are given below for correct and better understanding of the term Biodiversity:

1. As per D.L. Perlman and G. Andelson (1997) Biological diversity refers to the variety and variability among living organisms and the ecological complexes in which they occur.
2. Fidler and Jain (1992) defined Biological diversity as full range of variety and variability within and among the living organisms, their associations and habitat-oriented ecological complexes.
3. The International Council for Bird Preservation (1992) defined it as "Biodiversity is the total variety of life on earth. It includes all genes, species and ecosystems and the ecological processes of which that are the part".
4. Hunter (1996) states biodiversity as the diversity of life in all its forms, and at all levels of organizations. All levels of organizations indicate that biodiversity refers to the diversity of genes and ecosystems, as well as species diversity.
5. Mc Neely *et al*., (1990) define biodiversity as an umbrella term for the degree of nature's victory. It encompasses all species of plants, animals and micro-organisms and the ecosystems and ecological processes of which they are the part.

   Thus, the biodiversity can be seen as the measure of nature and its diversity, rather than an entity in itself, and is usually measured at three levels- genes, species and ecosystems.

   U.S. National Research Council (1992) defines it as "Biological diversity refers to the variety and variability among the living organisms and the ecological complexes in which they occur".

Ecosystem Diversity — **BIODIVERSITY** — **Genetic Diversity**

Species Diversity

However, the word "Biodiversity" is relatively new, and is thought to have first been coined as a contraction of the term "biological diversity" in 1985 and then popularised by a number of authors (Nematology: Advances and Perspectives, Vol. 1 By Z. X. Chen, S. Y. Chen, Donald Ward Dickson p 439)

Biodiversity is the variety of life on Earth, it includes all organisms, species, and populations; the genetic variation among these; and their complex assemblages of communities and ecosystems.

It also refers to the interrelatedness of genes, species, and ecosystems and in turn, their interactions with the environment. Three levels of biodiversity are commonly discussed — genetic, species and ecosystem diversity.

1. **Genetic diversity** is all the different genes contained in all the living species, including individual plants, animals, fungi, and microorganisms.

2. **Species diversity** is all the different species, as well as the differences within and between different species.

3. **Ecosystem diversity** is all the different habitats, biological communities and ecological processes, as well as variation within individual ecosystems.

7.3 BASIC CONCEPT

"Without knowing it, we utilize hundreds of products each day that owe their origin to wild animals and plants. Indeed our welfare is intimately tied up with the welfare of wildlife. Well many conservationists proclaim that by saving the lives of wild species, we may be saving our own." **Norman Myers**

Biodiversity is a shorthand way of saying biological diversity. Biodiversity includes all of the various forms of life on Earth. You might also know it as "the web of life". This web of life is divided into three parts to help simplify a very complex concept:

- Genes
- Species
- Ecosystems

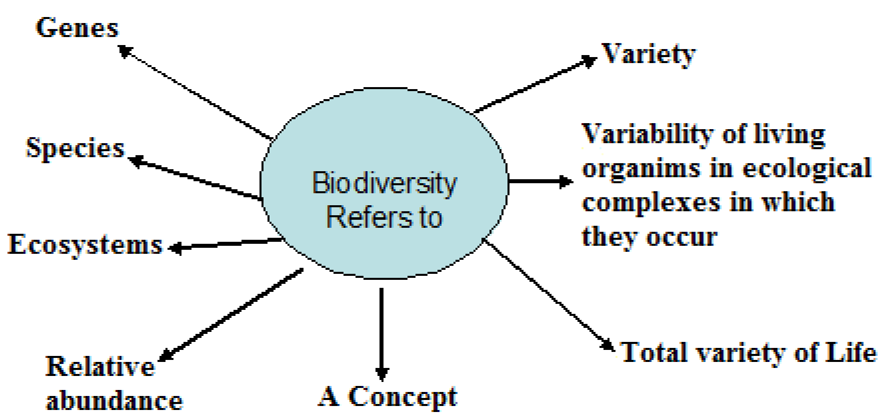


Fig.7.1 Biodiversity: Further Concepts
(Source: Modified from Biodiversity by D.L. Perlman and G. Andelson, 1997)

Michael J. Jeffries (1997) has elaborated biodiversity concept in Biodiversity and Conservation which directly and indirectly touches all areas of human lives. The concept of biodiversity also covers the following:

Evolution: Ecological processes have evolutionary consequence. They interact with genetic diversity via adaptation, micro-evolution and specialization.

Diversification of Genes: Selection and maintenance of genetic diversity.

Specialization of Diversity: There are three components to biodiversity: genetic, organizational and ecological. It covers conservation of genetic diversity, species variation and ecosystem diversity.

Table-1: Major themes within biodiversity. The presence of six main themes in texts from the conceptual origin of biodiversity in 1980 prior to the 1992 UN Convention on Biodiversity

Paper or Publication	**Lovejoy 1980**	**Norse and Mc Manus 1980**	**Norse et al., 1986**	**Biodiversity 1988**	**National Science Board 1989**	**Biological Diversity developing countries 1991**
Theme						
1. Inventory	Definition Global Sp. Total	Definition Global Sp. Total	Definition Global Sp. Total	Definition Global Sp. Total Habitat specific totals	Definition Global Sp. Total Gaps in Knowledge	Definition Global Sp. Total
2. Loss rates	Estimated losses due to forest destruction	Causes (settlement transport, fragmentation, agriculture, forestry, over exploitation, introduction of new species)		Global and habitat specific estimates, Geological patterns	Causes (human population growth, habitat loss, ecosystem function loss)	Habitat causes (development, market failure, interventions, habitat loss, over exploitations)
3. Value	Potential uses	Potential uses (food, energy, chemicals, raw materials, medicines)	Products (actual and poential). Ecosystem services, forestry, psychological well being	Medicine, Industry, food, Potential	Uses of organisms and plants	Use and non use values potential, habit examples
4. Economics	Valuation of ecosystem function		Timber production	Market failure to price biodiversity new economic approaches, pricing biodiversity	Economics of utilization (clothes, food, medicine and shelter)	Economic approaches to value biodiversity
5. Conservation		Gene banks, botanical gardens,	Concepts, Conservation	Priorities, case studies,	Recommendation s for research on	Aid policy procedures for

		species specific schemes, ecosystem management, legislation	and management of forests and rare species and laws	technologies reintroductions	inventories, education training and functioning in developing countries	priorities, habitat examples, criteria
6. Attitude		Philosophica, psychological affinity to life, right to exist	Ethics and stewardship	Green movement, society links to ecosystem morals, religion		Ethical value of biodiversity

7.4 BIODIVERSITY AT GLOBAL LEVEL

Conservative estimates of the existing biodiversity is ten million species, but if estimates for insects are correct then it could be around 30 million species, we have till now enlisted about 1.4 million species. It includes among others about 98% birds, 95% reptiles and amphibians, 90% fish and about 85% higher plants known to exist on this Earth (source: http://www.yourarticlelibrary.com/uncategorized/biodiversity-at-global-national-and-local levels-explained-with-diagram/28262/). Floral and faunal diversity at global level are presented in Tables 2 and 3.

Table-2: Biodiversity Profile: World: Plant Kingdom

Group	No. of species
Bacteria	4,000
Viruses	4,000
Algae	40,000
Fungi	72,000
Lichens	17,000
Bryophyta	16,000
Pteridophyta	13,000
Gymnosperms	750
Angiosperms	2,50,000

Table-3: Biodiversity Profile: World: Animal Kingdom

Group	No. of species
Protista	31,259
Mollusca	66,535
Arthropoda	9,87,949
Other Invertebrates	87,121
Protochordata	2,106
Pisces	21,723
Amphibia	5,150
Reptilia	5,817
Aves	9,026
Mamalia	4,629

7.5 BIODIVERSITY AT NATIONAL LEVEL

India, with 2.4% of the world's area, has over 8% of the world's total biodiversity, making it one of the 12 mega-diverse countries in the world. This status is based on the species richness and levels of endemism recorded in a wide range of taxa of both plants and animals. This diversity can be attributed to the vast variety of landforms and climates, resulting in habitats ranging from tropical to temperate and from alpine to desert. Adding to this is a very high diversity of human-influenced ecosystems, including agricultural and pasture lands, and a diversity of domesticated plants and animals, one of the World's largest. India is also considered one of the world's eight centres of origin of cultivated plants. Being a predominantly agricultural country, India also has a mix of wild and cultivated habitats, giving rise to very specialized biodiversity, which is specific to the confluence of two or more habitats.

Natural Ecosystems

Biogeographic Zones of India

Rodgers *et al*., (2002) recognizes ten biogeographic zones divided into twenty-six biotic provinces in India. Biogeographic zones of India and their spatial extent is presented in Table 4.

Table -4 Biogeographic zones of India and their spatial extent

S.No.	Zone	Area	% of India's land area
1	Trans-Himalaya	184823	5.62
2	Himalaya	210662	6.41
3	Desert	215757	6.56
4	Semi-Arid	545850	16.60
5	Western Ghats	132606	4.03
6	Deccan Peninsula	1380380	41.99
7	Gangetic Plain	354782	10.79
8	Coasts	82813	2.52
9	Northeast	171341	5.21
10	Islands	8249	0.25
	Grand Total	**3287263**	**100.00**

Natural Terrestrial Ecosystems

India, due to its varied physical features and its geographical location, experiences almost all kinds of climate, from tropical to alpine and from desert to humid. On the basis of temperature, the landmass of India can be broadly classified into four zones: a. *Tropical zone*, which is very hot round the year and does not have a winter, b. *Sub-tropical zone*, which is hot for most of the year but with a cool winter, c. *Temperate zone*, which has a warm summer and a pronounced winter, and, *Arctic or Alpine zone*, which has a short summer and a long and severe winter d. *Natural terrestrial ecosystems* are of the following broad kinds: forests, grasslands, deserts and permanently snow-bound areas (Source: Natural Terrestrial Ecosystems Thematic BSAP 2002).

Forests

According to FSI (2002), forest cover has been assessed to be 20.55% of the country's geographical area. Of this, dense forest areas cover 4,16,809 sq km (12.68 %) and open forests cover 2,58,729 sq km (7.87%) (MoEF & Kalpavriksh.2004). There have been various approaches to classifying forest ecosystems. One of the most comprehensive and detailed classifications of forests has been by Champion and Seth (1968), which is still in vogue in India. They have ecognised five major forest types: a) Tropical forests, b) Montane sub-tropical forests, c) Montane temperate forests, d) Sub-alpine forests, and, e) Alpine scrub. These are in turn classified into 16 major forest-type groups and 221 minor forest-type groups (Table-5). Besides this In India we have recorded forest areas classified as Reserve Forests (55%), Protected Forests (29%) and Unclassed Forests (16%).

Table -5: Forest Types As Classified By Champion and Seth (1968)

S.No.	Vegetation Type	Area (Million ha)	% of forest area
1	Tropical wet evergreen forest	4.5	5.8
2	Tropical semi-evergreen forest	1.9	2.5
3	Tropical moist deciduous forest	23.3	30.3
4	Littoral and swamp forest	0.7	0.9
5	Tropical dry deciduous forest	29.4	38.2
6	Tropical thorn forest	5.2	6.7
7	Tropical dry evergreen forest	0.1	0.1
8	Sub-tropical broad leaved forest	0.3	0.4
9	Sub-tropical pine forest	3.7	5.0
10	Sub-tropical dry evergreen forest	0.2	0.2
11	Montane wet temperate forest	1.6	2.0
12	Himalayan moist temperate forest	2.6	3.4
13	Himalayan dry temperate forest	0.2	0.2
14	Sub-alpine	3.3	4.3
15	Moist alpine forest	-	-
16	Alpine forest	-	-
	Total	**77**	**100**

Grasslands

Grasslands, variously called steppes, prairies, cerrados, pampas, savannahs, velds and rangelands in different parts of the world, are vegetation types with predominance of grass and grass-like species. In India, high-altitude grasslands of the Himalaya have been referred to as marg or bugiyal, and in Ladakh as tsang. Grasslands are plant communities with a more or less continuous layer of graminoids (grasses and grass-like plants), with or without a discontinuous layer of trees or shrubs. Grasslands are often associated with marked seasonality in precipitation, occurrence of fire and grazing by ungulates. Bamboo forests, though technically dominated by grasses, are not included under grasslands as they physically and in other respects resemble forests, and are usually mixed with a significant number of trees. Some research on this ecosystem was done by various workers (Singh and Gupta, 1993; Pandey and Singh, 1991; Melkania and Singh, 1989; and Singh *et al*., 1983). The grassland community builds an entirely different type of soil as compared to a forest, even when both start with the same parent material. Since grass-plants are short-lived as compared to trees, a large amount of organic matter is added to the soil. The first phase of decay is rapid, resulting in little litter, but much humus. Humification is rapid but mineralization is slow. Consequently grassland soils may contain 5-10 times as much humus as forest soils (Odum, 1971). As of 1992, the grassland coverage of the earth's terrestrial area was about 27% (Groombridge, 1992). For India, Olson *et. al*., (1983) put the cover of grassland and shrubland at 12% of the total landmass; however, the Planning Commission (PC 1988) estimates (MoEF & Kalpavriksh.2004) grassland coverage at 3.7%, and scientists at the Indian Grasslands and Fodder Research Institute, Jhansi, give an estimate of 3.9%, or about 120 lakh (12 million) hectares (Singh and Misri, 1993). The distribution of grasslands in India is quite uneven. For instance, in the western region, Rajasthan and Gujarat have 5.4% and 3.5% respectively of their land area under grasslands. In the eastern region, grasslands and pastures comprise less than 1% of the area, except in Sikkim, where they cover 13.3% of the land. The grasslands include such dissimilar ecosystems as the semi-arid pastures of the western part of the Deccan peninsula, the humid, semi-waterlogged tall grassland of the Terai belt, the rolling shola grasslands of the Western Ghats, hilltops, and the high-altitude alpine pastures of the Himalayas.

In India, grasses form the largest family of flowering plants. Out of an estimated 17500 species of flowering plants, about 1200 are grasses. About 360 grass taxa (almost 30%), are endemic to India. 172 endemics occur in the peninsular region, 56 in the north-east, 30 in the north-west, 5 in the western arid regions, 12 in the lower Gangetic plain, 4 in the Andaman and Nicobar Islands, and 50 endemics are spread over more than one of the above regions.

Deserts

Deserts (as distinct from desertified areas) are natural ecosystems characterized by very low rainfall (<600mm) arid and sparse presence of vegetation. Though appearing to be lifeless at first glance, deserts can harbour an astonishing and unique diversity of species, and biological communities of high conservation value. India broadly has three kinds of deserts: sandy warm desert in the far western region of Rajasthan; salt desert in the western region of Gujarat; and cold desert in the trans-Himalayan region of Ladakh in Jammu and Kashmir and Lahaul-Spiti in Himachal Pradesh.

The Great Indian Thar Desert is an important bio-region of Rajasthan comprising about 61 percent of the state's total geographical area. It is one of the most biologically and culturally diverse deserts of the world, and houses distinct and unique ecosystems, landscapes and species of plants and animals. It is characterised by geomorphic forms and landscapes such as dunes, magras, dhands and bhakars, each with a distinct ecology of its own. It is an extension of the Sahara desert, through the Arabian and Persian deserts. It extends from Punjab through

Haryana and Rajasthan to Gujarat. The desert results from the dryness of the prevailing monsoon winds, which do not bring sufficient rain to keep the region moist. The desert presents an undulating surface, with high and low sand dunes separated by sandy plains and low, barren hills, or bhakars, which rise abruptly from the surrounding plains.

The Salt Desert or the Rann of Kachchh is distinguished from the Thar Desert by its exceptional salinity (Rann in the local language means salt desert), caused by seasonal inundation by the sea into a vast area inland. The extraordinary intermingling of saline, marshy and coastal desert ecosystems found in the Rann is perhaps the only one of its kind in the world. The Great Rann of Kachchh and the Little Rann of Kachchh, with an area of about 16780 sq km and 5180 sq km respectively, constitute the entire Rann of Kachchh. The average altitude is about 15 m above mean sea level, and it thus appears like a table-top surface. Ecologically, it represents one of the largest seasonal saline wetland areas, having water depth ranging from 0.5 to 1.5 m. The Little Rann of Kachchh is world famous for the last remaining population of the endemic Wild Ass, and almost the entire Little Rann is covered under WAS to protect this species.

The Cold Desert, sprawled over a vast area north of the Himalayan ranges, is an ecosystem of exceptionally low temperatures (down to -75°C) and rainfall (500-800 mm annually). It forms a plateau at a height of 4,500 to 6,000 meters above mean sea level, and is encompassed by the Trans-Himalayan Biogeographic Zone (Rodgers and Panwar, 1988). This zone extends into the Tibetan plateau, to cover an area of 2.6 million sq km, from which originated the great river systems of the Indus, Sutlej, Brahmaputra and Yangtze. In India, cold deserts cover a vast area of 1, 09, 990 sq km, about 87,780 sq km in Ladakh (Kashmir), and 22,210 sq km in Lahaul-Spiti (Himachal Pradesh). Lahaul and Spiti is delimited by the Pir Panjal range, the Great Himalayan range, and the Zanskar range. The Great Himalayan range with a mean elevation of 5,500 m extends from Kunzam range to Baralacha and Pin Parvati range, separating the Chamba-Beas basin from the Sutlej-Spiti basin around Pooh, and pierced by the Sutlej at Kalpa. The Zanskar is distinguished by highly evolved life forms, including a variety of aromatic and medicinal plants, several wild relatives of domesticated plants (barley, gooseberry, garlic) and animals (four species of wild sheep and goats) and a charismatic mega-fauna, still preserved in its entirety, unlike in most other parts of the world.

Natural Aquatic Ecosystems

India has a rich variety of wetland and aquatic habitats, ranging from small streams and village ponds through large lakes and reservoirs, some of the longest rivers in the world, coastal lagoons, estuaries and backwaters, the unique Rann of Kachchh, coral reefs and mangroves, to open coastal and oceanic waters. India's wetlands can be grouped, based on salinity, into two major categories marine, and brackish or freshwater, within each of which there are several different ecosystems.

Marine Ecosystems

India has a long coastline, estimated to range between about 8000 km (Ramakrishna and Venkataraman, 2002) and 8130 km (CMFRI, 1998-99). India occupies the tenth place in terms of coastline length of all maritime countries and seventh place in terms of the extent of the Exclusive Economic Zone (2.02 million sq km) adjoining the continental region and the offshore islands. The long coastline and the tropical climate favour a multitude of coastal and offshore marine ecosystems.

Fresh and brackish water Systems (Wetlands)

The Ramsar Convention (Ramsar, 1993) defines wetlands as 'areas of submerged or water saturated lands, both natural or artificial, permanent or temporary, with water that is static or flowing, fresh or brackish, or salty including area of marine water, the depth of which at low tide does not exceed six meters' (IUCN, 1971). The freshwater ecosystems encompass a wide spectrum of habitats covering both lentic and lotic water bodies. The former includes either temporary or permanent ponds, lakes, floodplain marshes and swamps while the latter relate to rivers and streams.

Brackish water ecosystems like the estuaries and coastal lagoons are also classified as wetlands. The natural freshwater wetlands can be broadly classified into three major categories with 15 predominant wetland types (Table 6).

Table-6: Categories of Natural Freshwater Wetlands (Source: Scott 1989; Dugan 1990)

Type	Nature of flow	Sub type
Riverine	Perennial	i. Permanent rivers and streams, including waterfalls
		ii. Inland deltas
	Temporary	i. Seasonal and irregular rivers and streams
		ii. Riverine floodplains, including river flats, flooded river basins, seasonally flooded grasslands
Lacustrine	Permanent	i. Permanent freshwater lakes (>8 ha), including shores subject to seasonal or irregular inundation
		ii. Permanent freshwater ponds (<8 ha)
	Seasonal	i. Seasonal freshwater lakes (>8 ha), including floodplain lakes
Palustrine	Emergent	i. Permanent freshwater marshes and swamps on inorganic soil with emergent vegetation whose bases lie below the water table for at least most of the growing season
		ii. . Permanent peat-forming freshwater swamps, including tropical upland valley swamps dominated by *Papyrus* or *Typha*
		iii. Seasonal freshwater marshes on inorganic soil, including sloughs, potholes, seasonally flooded meadows, sedge marshes, and dambos
		iv. Peatlands, including acidophilous, ombrogenous, or

		soligenous mires covered by moss, herbs or dwarf shrub vegetation, and fends of all types
		v. Alpine and polar wetlands, including seasonally flooded meadows moistened by temporary waters from snowmelt
		vi. Volcanic fumaroles continually moistened by emerging and condensing water vapour
	Forested	i. Shrub swamps, including shrub-dominated fresh-water marsh, shrub carr and thickets, on inorganic soils
		ii. Freshwater swamp forest, including seasonally flooded forest, Wooded swamps on inorganic soils
		iii. Forested peat lands, including peat swamp forest

Floristic diversity in different groups

About 45,000-47,000 plant species are reported from India, representing 11% of the known world flora (Mudgal and Hajra, 1999; Singh and Karthikeyan 2000 and 2001). About 33% flowering plant species and 29% of the total Indian flora are endemic. Indian flora shows affinity with the flora of several countries and regions, due to the continuity of the northern part of India's landmass with the Middle East, the former USSR, Central Asia, China and east Asia. Some elements in Indian flora belong to distant places like Africa and Australia and thus show discontinuous distribution. Besides, the flora of north-eastern India has rich admixture of floristic elements of Malaysian, Burmese, Sino Tibetan, Japanese and, to a lesser degree, even of Australian region. Similarly, certain floristic elements of Western India and the Ghats of the peninsular region are common with Sri Lanka and eastern parts of South Africa. The flora of the Andaman group of islands has more in common with the flora of Myanmar, while the flora of the Nicobar group of Islands show affinity with the flora of Indonesia and Malaysia (Jain and Sastry, 1983). Comparative account of floristic diversity of India is presented in Table-7.

Table-7: Floral diversity of India

Group	No. of species	% of India to World
Bacteria	850	21.25
Viruses	Unknown	---------
Algae	6500	16.25
Fungi	14,500	20.14
Lichens	2000	11.80
Bryophyta	2850	17.80
Pteridophyta	1100	8.46
Gymnosperms	64	8.53
Angiosperms	17500	7

Distribution of wild relatives in different crop groups

India is one of the world's 12 Vavilovian Centres of origin and diversification of cultivated plants, known as the 'Hindustan Centre of Origin of Crop Plants' (Vavilov, 1951). These wild relatives of crop plants (WRCPs) constitute a rich reservoir of genetic variation (MoEF & Kalpavriksh. 2004). About 320 species of these wild relatives (116 genera and 48 families) are known to have originated in India (Arora and Nayar, 1984). The distribution of these crop groups is presented in **Table** 8.

Table -8: Wild relatives of some crops in India

Crop	No. of wild relatives
Millets	51
Fruits	104
Spices & condiments	27
Vegetables & pulses	55
Fibre crops	24
Oil seed, tea, coffee, tobacco & sugarcane	12
Medicinal Plants	3000

Threatened floral species in India by threat category (2002 Red List)

Despite the migration of floristic elements from other contiguous or neighbouring regions, India has a very high number of endemic elements. About 33% of the Indian flowering plants (5725 species, 146 genera, 47 families) are regarded as endemic; they are mainly located in 24 centers of the country (Nayar, 1996). Besides endemics, nearly 10% of flowering plants are assessed under various categories of threatened species. The Red Data Book of Indian Plants listed 620 threatened species. Of these, 28 are presumed extinct, 124 endangered, 81 vulnerable, 160 rare and 34 insufficiently known (Nayar and Sastry, 1987, 1988).

Wild Animal (Including Protozoan) Diversity

India has a very rich range of fauna, which is still far from completely documented. Nearly 90,000 species of fauna have been reported from India, a little over 7% of the world's reported animal diversity. Faunal diversity, degree of endemism and list of threatened species is presented in table 9.

Table- 9: Faunal diversity of India

Group	No. of species
Protista	2577
Mollusca	5070
Arthropoda	68389
Other Invertebrates	8329

Protochordata	119
Pisces	2546
Amphibia	209
Reptilia	456
Aves	1232
Mammalia	390

Micro-Organisms

Micro-organisms are ubiquitous in distribution. They represent the earliest life-forms and have been around for 3.6 to 4.0 billion years on the earth. Fossil evidence of microbial life has been found in rocks containing diverse prokaryotes (simple unicellular organisms without a defined nucleus). The origin of eukaryotic (complex, multicellular organisms with a well defined nucleus) life has also stemmed from the fundamental contributions of bacteria, in the form of chloroplasts and mitochondria (Micro-organic Diversity Thematic BSAP) The number of microbial cells is estimated to be about 4-6x1030, containing nearly half the total carbon and 90% of the nitrogen and phosphate on this planet. It may be noted that micro-organisms are the only living forms which are present under the most difficult habitats and extreme environments like Bore water, deep sea vents, salt pans, the interiors of rocks, acid mine drainage, extreme cold environments and almost all other conceivable conditions harbour micro-organisms. Unlike animals and plant species that are restricted in terms of geographical areas due to the climate and natural borders between the continents, most micro-organisms (especially bacteria and archaea) are found across the continents and are truly cosmopolitan. It is estimated that over 1.3 million endophytic microbes await discovery. Diversity of microbes in different ecosystems is important not only in isolated species but in consortia as well. In addition, human-made habitats also contain diverse types of microbes. It has been estimated that out of the microbial diversity worldwide, only about 5-10% is known based on the analysis of culturable microbes (MoEF & Kalpavriksh, 2004).

Agricultural Ecosystems

Agroclimatic Zones of India

From the desert ecosystem of Rajasthan in the West to the flood plain systems of Bengal in the East, from the mountain agriculture of the Himalayas to the wetland ecosystems of Kerala, from the semi-arid rainfed ecosystems in the Deccan plateau to the highly developed terraces of Northeast, the wide-ranging agro-ecosystems in India offer a mind-boggling variety. They also represent a fascinating array of practices which embody a vast expanse of agriculture-related knowledge systems of local rural communities. As per Murthy and Pandey (1978) there are eight broad agricultural zones in India: 1. Humid Western Himalaya, 2. Humid Bengal-Assam, 3. Humid Eastern Himalayan Region and Bay Islands (MoEF & Kalpavriksh, 2004), 4. Sub-Humid Satluj Ganga Alluvial Plains, 5. Sub-Humid to Humid

Eastern and South-Eastern Uplands, 6. Arid Western Plains, 7. Semi-Arid Lava Plateaus and Central Highlands, 8. Humid to Semi-Arid Western Ghats and Karnataka Plateaus but as per the Planning Commission of India, (1985-1990), 15 broad agro-climatic zones are (based on physiography and climate): 1. West Himalayan Region, 2. East Himalayan Region, 3. Lower Gangetic Plains Region, 4. Middle Gangetic Plains Region, 5. Upper Gangetic Plains Region, 6. Trans-Gangetic Plains Region, 7. Eastern Plateau and Hill Region, 8. Central Plateau and Hill Region, 9. Western Plateau and Hill Region, 10. Southern Plateau and Hill Region, 11. East Coast Plains and Hill Region, 12. West Coast Plains and Ghats Region, 13. Gujarat Plains and Hill Region, 14. Western Dry Region, and 15. The Island Region.

But as per the National Bureau of Soil Survey and Land Use Planning of the Indian Council for Agricultural Research, a set of 21 agro-ecological regions has been delineated based on physiography, soil types, bioclimate, and length of crop-growing period (Sehgal *et. al.*, 1990), which are 1. Western Himalayas: Cold arid ecoregion with shallow skeletal soils, Length of growing period (LGP) < 90 days, 2. Western Plain and Kutch Peninsula: Hot arid ecoregion with desert and saline soils. LGP < 90 days, 3. Deccan Plateau: Hot arid ecoregion, with mixed red and black soils, LGP < 90 days, 4. Northern Plain and Central Highlands: Hot semi-arid ecoregion with alluvium derived soils. LGP 90-150 days. Central (Malwa) Highlands and Kathiawar Peninsula: Hot semi-arid ecoregion with medium and deep black soils. LGP 90-150 days. 5. 6. Deccan Plateau: Hot semi-arid ecoregion with shallow and medium (inclusion of deep) black soils. LGP 90-150 days, 7. Deccan Plateau and Eastern Ghats: Hot semi-arid ecoregion with red and black soils, LGP 90-150 days (MoEF & Kalpavriksh, 2004), 8. Eastern Ghats (Tamil Nadu uplands and Deccan Plateau: Hot semi-arid ecoregion with red loamy soils, LGP 90-150 days, 9. Northern Plain: Hot sub-humid ecoregion with alluvium-derived soils. LGP 150-180 days, 10. Central Highlands (Malwa and Bundelkhand): Hot sub-humid ecoregion with medium and deep black soils, LGP 90-150 days. Deccan Plateau and Central and Highlands (Bundelkhand): Hot sub-humid ecoregion with mixed red and black soils. LGP 150-180 days, 11. 12. Eastern Plateau (Chhattisgarh): Hot sub-humid ecoregion with red and yellow soils, LGP 150-180 days, 13. Eastern (Chhota Nagpur) Plateau and Eastern Ghats: Hot sub-humid ecoregion with red loamy soils, LGP 150180 days, 14. Eastern Plain: Hot sub-humid ecoregion with alluvium-derived soils. LGP 180-210 days, 15. Western Himalayas: Warm sub-humid (inclusion humid) ecoregion with brown forest and podzolic soils, LGP 180-210 days, 16. Assam and Bengal Plains: Hot humid ecoregion with alluvium-derived soils, LGP > 210 days, 17. Eastern Himalayas: Warm perhumid ecoregion with brown and red hill soils, LGP > 210 days, 18. Northern Eastern Hills (Purvanchal): Warm perhumid ecoregion with red and lateritic soil, LGP > 210 days, 19. Eastern Coastal Plains: Hot sub-humid ecoregion with alluvium-derived soils, LGP 150-210 days, 20. Western Ghats and Coastal Plains: Hot humid perhumid ecoregion with red, lateritic and alluvium soil, LGP >210 days, and 21. Islands of Andaman and Nicobar and Lakshadweep: Hot perhumid ecoregion with red loamy and sandy soils. LGP > 210 days.

7.6 THREATS TO BIODIVERSITY

Human civilization and economic activity put pressure on aspects of biodiversity. The present rate of extinction is believed to be much higher than can be explained totally by natural causes. We must be careful to balance our needs with those of other species. There are many threats to our natural world, which include:

a. Habitat loss and destruction
b. Alteration in ecosystem composition
c. Invasive alien species
d. Over exploitation
e. Population and contamination and
f. Global climate change

What's happening?

Fast isn't always good. Species are becoming extinct at the fastest rate known in geological history, and most of these extinctions are tied to human activity. Some conservation organizations estimate species are heading towards extinction at a rate of about one every 20 minutes (Conservation International http://www.conservation.org/act/ get involved/ Pages/ stoptheclock.aspx). One figure frequently cited is that the rapid loss of species we are seeing today is estimated to be between 1,000 and 10,000 times higher than the natural extinction rate. Experts calculate that between 0.01 and 0.1 per cent of all species will continue to become extinct each year, if we carry on with business as usual. That may not sound like very much, but consider that if there are 100 million species on Earth as some estimates suggest, then between 10,000 and 100,000 species are becoming extinct each year. Looking at recent assessments we know that more than one third of species assessed in a 2009 major international biodiversity study are threatened with extinction. Of the 47,677 species in the IUCN Red List of Threatened Species of 2009, 17,291 are deemed to be at serious risk (http://cms.iucn.org/ about/work/programmes/ species/ red_list/about_the_red_list/). The list reveals that 21 per cent of all known mammals, 30 per cent of all known amphibians, 12 per cent of all known birds, 28 per cent of reptiles, 37 per cent of freshwater fishes, 70 per cent of plants and 35 per cent of invertebrates assessed so far, are under threat.

7.7 SUMMARY

This Module provides a global overview of the different definitions of biodiversity proposed by different workers from time to time, various concepts behind the Conservation of Biological Diversity in general and particular as per the Convention of Biological Diversity (CBD), and various types of ecosystems and their percentage share of faunal and floral diversity of the globe as well as India. Further, various levels of biodiversity, further concept and major themes within the biodiversity were also discussed for the better understanding of the students. Also an attempt has been made to discuss various ecosystem diversity of the India including Agricultural Ecosystem and their share in Indian Biodiversity. Further, threats also pose a serious problem in the conservation of the biodiversity therefore different kinds of threats responsible for the depletion of the biodiversity was also discussed. Current hypothesis with all clarifications regarding the loss of biodiversity was also presented in this module.

7.8 GLOSSARY

CBD: Convention on Biological Diversity
WCMC: World Conservation Monitoring Centre
Genes: The basic biological unit of heredity. Genes of an individual belonging to the same species are similar and genes control the characteristics of particular species.
Species: A species is often defined as a group of individuals that actually or potentially interbreed in nature. In this sense, a species is the biggest gene pool possible under natural conditions.
Ecosystem: An ecosystem includes all of the living things (plants, animals, and microorganisms in a given area, interacting with each other, and also with their non-living environments
FSI: Forest Survey of India
MoE&F: Ministry of Environment and Forests
WAS: Wild Ass Sanctuary
IUCN: International Union for Conservation of Nature and Natural Resources

7.9 SELF ASSESSMENT QUESTIONS

7.9.1 Multiple Choice questions

1- Who coined the term biodiversity?
(i) Lovejoy (ii) E.P. Odum
(iii) S.K. Jain (iv) E.O. Wilson

2- How many levels Biodiversity have?
(i) Four (ii) Five
(iii) Three (iv) Two

3- India constitutes …………….. % of world's flora?
(i) 2.4 (ii) 3.4
(iii) 4.4 (iv) 1.4

4- How many Biogeographic zones we have in India?
(i) 11 (ii) 12
(iii) 10 (iv) 5

5- How many forest types we have in India?
(i) 10 (ii) 16
(iii) 14 (iv) 6

6- The Great Indian Thar Desert is an important bio-region of …………………?
(i) Uttar Pradesh (ii) Rajasthan
(iii) Uttarakhand (iv) Jammu and Kashmir

7- The Ramsar Convention is for…………………
(i) Wetlands (ii) Forests
(iii) Grasslands (iv) Alpine regions

8. ……………..% flora of India is endemic?
(i) 35 (ii) 29
(iii) 46 (iv) 28

7.9.1 Answers Key: 1-(i); 2-(iii); 3-(i); 4-(iii); 5-(ii); 6-(ii); 7-(i); 8-(ii)

7.10 REFERENCES

- Lovejoy, T. E. (1980). The Global 2000 Report to the President (G. O. Barney, ed.), Vol. 2, The Technical Report, pp. 327–332. Penguin, New York.
- Wilson, E. O., and Peter, F. M. (1988). Biodiversity. National Academy Press, Washington, D.C.
- CBD. (1992). Convention of Biological Diversity (CBD), United Nations.
- D.L. Perlman and G. Andelson. (1997). Biodiversity: exploring values and priorities in conservation. Blackwell Sciences United States of America
- Fiedler, P. L., and Jain, S. K. (1992). Conservation Biology: The Theory and Practice of Nature Conservation, Preservation and Management. Chapman and Hall, New York
- Hunter, M. L., Jr. (1996). Fundamentals of Conservation Biology. Blackwell Science, Cambridge, Massachusetts
- McNeely, J. A., Miller, K. R., Reid, W. V., Mittermeier, R. A., and Werner, T. B. (1990). Conserving the World’s Biological Diversity. International Union for Conservation of Nature and Natural Resources/World Resources Institute/Conservation International/World Wildlife Fund–U.S./World Bank, Gland, Switzerland/Washington, D.C.
- Z. X. Chen, S. Y. Chen. (1992). Nematology: advances and perspectives, Vol. 1 By, Donald Ward Dickson p 439.). U.S. National Research Council.
- Michael J. Jeffries. (1997). Biodiversity and Conservation. 2nd edition. Routlegde Taylor and Francis Group. London and NY.

- Rodgers W.A., Panwar H.S., Mathur V.B. 2002. Executive summary. In: Wildlife protected networks in India. A review. Wildlife Institute of India, Dehra Dun, India. Pp. 44.
- FSI. (2002). Atlas: Forest Types of India. Forest Survey of India, Dehradun (India)
- Champion, H. G. and Seth, S. K. (1968). A Revised Survey of Forest Types of India, Govt. of India Press, New Delhi, p. 404.
- Singh, J.S. and Gupta, S.R. (1993).Grasslands of Southern Asia. In: Coupland, R.T. (ed.) Natural Grasslands, Eastern Hemisphere and Resume, Ecosystem of the World, 8B, Elsevier.
- Pande, P., Kothari, A and Singh, S. (1991). Directory of National Parks and Sanctuaries in Andaman and Nicobar Islands: Management Status and Profiles, Indian Institute of Public Administration, New Delhi
- Melkania, N.P. and J.S. Singh (1989). Ecology of Indian Grasslands. In: J.S. Singh and B. Gopal (eds.) Prespectives in Ecology, Jagmander Book Agency, New Delhi.
- Singh, J.S., Lauenroth, W.K. and Milchunas, D.G. (1983). Geography of grassland ecosystem. Prog. Geogr. 7:46-80.
- Odum, E.P. (1971). Fundamentals of Ecology.
- Groombridge, B. (1992). Global Biodiversity. Status of the Earth's Living Resources. A Report Compiled by the World Conservation Monitoring Centre, xx + 585 pp. London, Glasgow, New York, Tokyo, Melbourne, Madras: Chapman & Hall.
- Olson et. al., (1983). Major World Ecsosystem Complexes ranked by carbon in live vegetation: a data base. US Department of Energy.
- Singh, P and Bimal Misri (1993). Rangelands resources utilization and management in India. Paper presented at International Symposium on Grassland Resources. Huhehot, Inner Mongolia, P.R.China.
- Rodgers, W.A. and Panwar, H.S. (1988). *Planning a wildlife protected area network in India*. 2 vols. Project FO: IND/82/003. FAO, Dehra Dun. 339, 267 pp.
- Ramakrishna and Venkataraman, K., 2002. Marine Ecosystems. In: Alfred, J.R.B., Das, A.K. and Sanyal, A. K. (ed.), Ecosystems of India, Zoological Survey of India, Kolkata, 1-410.
- CMFRI. (1998-99). Central Marine Fisheries Research Institute. Indian Council of Agricultural Research, Cochin.
- IUCN. (1971). IUCN Yearbook: Annual report of the International Union for Conservation of Nature and Natural Resources for 1970.
- Scott, J. M., Davis, F., Csuti, B., Noss, R., Butterfield, B., Grove, C., Anderson, S, H., Caicco, S., Derchia, F., Edwards, T. C., Jr., Ullman, J., and Wright, R. G. (1993). GAP analysis: A geographic approach to protection of biological diversity. Wildl. Monogr. 123, 1–41.
- Dugan, P.J. (1990): Wetland Conservation: A Review of Current Issues and Required Action, Gland, Switzerland: IUCN, the World Conservation Unit.

- Mudgal V, Hajra P. K. (1999). Floristic Diversity and Conservation Strategies in India: In situ and ex situ conservation. Botanical Survey of India, Ministry of Environment and Forests.
- Singh NP, Karthikeyan S. (2000). Flora of Maharashtra State: Dicotyledones, Vol. I (Ranunculaceae to Rhizophoraceae) Botanical Survey of India.
- Singh, NP, Lakshminarasimhan P, Karthikeyan S, Prasanna PV. (2001). Flora of Maharashtra State: Dicotyledones, Vol. 2: (Combretaceae to Ceratophyllaceae), Botanical Survey of India.
- Jain, S.K. and Sastry, A.R.K. (1983). Materials for a catalogue of threatened plants of India. Botanical Survey of India, Howrah.
- Vavilov, N. I. (1951). The origin, variation, immunity and breeding of cultivated plants. Chronicles Bot. Volume 13. 364 pp.
- Arora, R.K. and E.R. Nayar. (1984). Wild relatives of crop plants in India. NBPGR Sci. Monogr. No. 9. 90 p.
- Nayar, M.P. (1996). Hotspots of Endemic Plants of India, Nepal and Bhutan. TBGRI.
- Sehgal, J.C., D.K. Mondal, C. Mondal and S. Vadi. (1990). Agro-ecological regions of India. NBSS Tech. Bull. No. 24. NBSS & UP, Nagpur. 73 p.
- Nayar, M.P. and Sastry, A.R.K. (1987). Red Data Book of Indian Plants. Vol. 1. Botanical Survey of India, Calcutta. 257
- Nayar, M.P. and Sastry, A.R.K. (1988). Red Data Book of Indian Plants. Vol.2. Botanical Survey of India, Calcutta.
- Nayar, M.P. and Sastry, A.R.K. (1990). Red Data Book of Indian Plants. Vol. 3. Botanical Survey of India, Calcutta.
- Murthy, R.S. and S. Pandey (1978): Delineation of Agro-Ecological Regions of India, Paper presented in Commission V 11th Congress of ISSS, Edmonton, Canada.

7.11 SUGGESTED READING

- Huston, M. A. (1994). Biological Diversity: The Coexistence of Species on Changing Landscapes. Cambridge University Press, New York
- Vold, T. and D.A. Buffett (eds.). 2008. Ecological Concepts, Principles and Applications to Conservation. Available at: www.biodiversitybc.org
- MoE&F & Kalpavriksh. 2004. National Biodiversity Strategy and Action Plan, India: Final Technical Report of the UNDP/GEF Sponsored Project.
- MOE&F. 2009. India’s Fourth National Report to the Conventional on Biological Diversity.

7.12 TERMINAL QUESTIONS

1. Define biodiversity. Explain the interrelationship between natural vegetation, wildlife and micro-organisms.
2. What are the main causes of loss of biodiversity? State any four.

3. Describe biodiversity profile at global and national level with suitable examples.
4. Justify the need for conservation of natural vegetation, wildlife and microorganisms with suitable reasons.
5. Categorize the following statements into narrowly utilitarian, broadly utilitarian and ethical reason and justify your categorization also.
i) Every species in biodiversity has an intrinsic value even if it is not of value to us.
ii) Human beings device a number of economic benefits like food, fibre etc from Biodiversity.
iii) Biodiversity provides ecosystem services which cannot be given price tag.
6. What are the various threats to the biodiversity? Discuss the causes of loss of biodiversity.
7. Why Biodiversity does not have political boundaries?

UNIT-8 BIODIVERSITY CONSERVATION - *IN SITU* AND *EX SITU*

Contents

8.1 OBJECTIVES

After reading this unit students will be able-

- to know about the concepts behind conservation
- various methods of conservation i. in-situ and ii. ex-situ with suitable examples
- issues/concerns related to the conservation
- to know about the Indian scenario of germplasm collection and National Institute involved in the germplasm collection

8.2 INTRODUCTION

Conservation of biodiversity is of utmost importance in ensuring the protection of healthy environment over the globe and also for meeting the basic needs of food, nutrition, health care, clothing and many more. At the Earth Summit in Rio de Janeiro, June 1992, a biodiversity convention was signed by more than 150 countries. The signatories committed to "conserve the variety of animals and plants within their jurisdiction."

Conservation is the protection, preservation, management, or restoration of wildlife and natural resources such as forests and water. Through the conservation of biodiversity and the survival of many species and habitats which are threatened due to human activities can be ensured. There is an urgent need, not only to manage and conserve the biotic wealth, but also restore the degraded ecosystems.

Why we should all value the biodiversity of the earth:

1) Moral reasons. A culture that encourages respect and stewardship for wildlife and landscapes is preferable to a culture which does not take these things seriously.

2) Aesthetic reasons. Landscapes and species should all be conserved because they are beautiful and enrich the lives of humans.

3) Providing important natural functions. Ecosystems serve humans because they provide natural functions. For example, the microbes in an ecosystem are vital in the breakdown of dead plant and animal remains and in the recycling of nutrients.

4) Biodiversity provides actual and potential material and economic benefits to people.

5) Continuance of evolutionary processes.

6**) Insurance.** No one knows what humans may need in the future. If species have become extinct, humans can never benefit from them.

Generally, Conservation is defined as the management of human use of the biosphere so that it may yield the sustainable benefit to the present generations, while maintaining its potential to meet the needs and aspirations of future generations. Now, it has become clear that biodiversity is the cornerstone of our existence on Earth. It is also important to conserve biodiversity for the sake of our own curiosity and aesthetic appreciation.

Issues/concerns related to the conservation

There are a number of issues and concerns related to the conservation of biodiversity which are summarized below:

1. Inventorization and proper documentation
2. Patenting of indigenous knowledge through products, novelties, processes and techniques
3. Value addition
4. Several threats to biodiversity
5. Excessive collection of plant genetic resources and it's over exploitation, poisoning by peptides/pollutants, exotic taxa etc.
6. Passport data and their evaluation data of germplasm
7. Urged need for exploration of some more wild varieties, landraces to fill the gap
8. Building partnership in conservation of biodiversity in between ICAR, NBPGR, NDRI and several national and regional stations
9. Human Resource Development and training at National and International level of organizations, directly associated with conservation programme
10. Promote and strengthen and generate awareness or conservation of genetic resources among the common populace

8.3 BIODIVERSITY CONSERVATION

Generally, there are two basic strategies involved for the conservation purposes like in-situ and ex-situ.

8.3.1 In-situ conservation (National parks, Sanctuaries and Biosphere reserves)

In-situ conservation, the conservation of species in their natural habitats, is considered the most appropriate way of conserving biodiversity.

Conserving the areas where populations of species exist naturally is an underlying condition for the conservation of biodiversity. That's why protected areas form a central element of any national strategy to conserve biodiversity. It aims at conserving biota in their natural habitats on a holistic basis more as a system than as separate individuals. The aim is to conserve an integrated system (ecosystem) of plants, animals (wildlife) and microorganisms with its particular atmosphere, hydrosphere and lithosphere under such conditions, there are opportunities for mutualism, co-adaption and co-evolution together with the processes like mutation, recombination and natural selection which work unfettered leading to the survival of the fittest.

The most commonly referred in-situ conservation sites include:
1-Sanctuary
2-National Park
3- Biosphere reserve
4- Conservation Reserve
5- Community Reserve

1-Sanctuaries

Sanctuary is an area which is of adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The Sanctuary is declared for the purpose of protecting, propagating or developing wildlife or its environment. Certain rights of people living inside the Sanctuary could be permitted. Further, during the settlement of claims, before finally notifying the Sanctuary, the Collector may, in consultation with the Chief Wildlife Warden, allow the continuation of any right of any person in or over any land within the limits of the Sanctuary (Source: http://www.moef.nic.in/downloads/public-information/protected-area-network.pdf).

2-National Parks

National Park is an area having adequate ecological, faunal, floral, geomorphological, natural or zoological significance. The National Park is declared for the purpose of protecting, propagating or developing wildlife or its environment, like that of a Sanctuary. The difference between a Sanctuary and a National Park mainly lies in the vesting of rights of people living inside. Unlike a Sanctuary, where certain rights can be allowed, in a National Park, no rights are allowed. No grazing of any livestock shall also be permitted inside a National Park while in a Sanctuary; the Chief Wildlife Warden may regulate, control or prohibit it. In addition, while any removal or exploitation of wildlife or forest produce from a Sanctuary requires the recommendation of the State Board for Wildlife, removal etc., from a National Park requires recommendation of the National Board for Wildlife (However, as per orders of Hon’ble Supreme Court dated 9th May 2002 in Writ Petition (Civil) No. 337 of 1995, such removal/ exploitation from a Sanctuary also requires recommendation of the Standing Committee of National Board for Wildlife) (Source: http://www.moef.nic.in/downloads/public-information/protected-area-network.pdf).

3-Biosphere Reserves

Biosphere reserves are areas of terrestrial and coastal ecosystems promoting solutions to reconcile the conservation of biodiversity with its sustainable use. They are internationally recognized, nominated by national governments and remain under sovereign jurisdiction of the states where they are located. Biosphere reserves serve in some ways as 'living laboratories' for testing out and demonstrating integrated management of land, water and biodiversity. Collectively, biosphere reserves form a world network: the World Network of Biosphere Reserves (WNBR). Within this network, exchanges of information, experience and personnel are facilitated. There are over 500 biosphere reserves in over 100 countries (Source: http://www.unesco.org/mab/doc/faq/brs.pdf).

4-Conservation Reserves

Conservation Reserves can be declared by the State Governments in any area owned by the Government, particularly the areas adjacent to National Parks and Sanctuaries and those areas which link one Protected Area with another. Such declaration should be made after having consultations with the local communities. Conservation Reserves are declared for the purpose of protecting landscapes, seascapes, flora and fauna and their habitat. The rights of people living inside a Conservation Reserve are not affected. (Source: http://www.moef.nic.in/downloads/public-information/protected-area-network.pdf).

5-Community Reserves

Community Reserves can be declared by the State Government in any private or community land, not comprised within a National Park, Sanctuary or a Conservation Reserve, where an individual or a community has volunteered to conserve wildlife and its habitat. Community Reserves are declared for the purpose of protecting fauna, flora and traditional or cultural conservation values and practices. As in the case of a Conservation Reserve, the rights of people living inside a Community Reserve are not affected (Source: http://www.moef.nic.in/downloads/public-information/protected-area-network.pdf).

Table-1: State-wise details of the Protected Areas Network of the Country

S.No.	State/UT	National Parks	Wildlife Sanctuaries	Conservation Reserves	Community Reserves
1	Andhra Pradesh	6	21	0	0
2	Arunachal Pradesh	2	11	0	0
3	Assam	5	18	0	0
4	Bihar	1	12	0	0
5	Chhatisgarh	3	11	0	0
6	Goa	1	6	0	0
7	Gujarat	4	23	1	0
8	Haryana	2	8	2	0
9	Himachal Pradesh	5	32	0	0
10	Jammu &Kashmir	4	15	34	0
11	Jharkhand	1	11	0	0
12	Karnataka	5	22	2	1
13	Kerala	6	16	0	1
14	Madhya Pradesh	9	25	0	0
15	Maharashtra	6	35	1	0
16	Manipur	1	1	0	0
17	Meghalaya	2	3	0	0
18	Mizoram	2	8	0	0
19	Nagaland	1	3	0	0
20	Orissa	2	18	0	0
21	Punjab	0	12	1	2
22	Rajasthan	5	25	3	0
23	Sikkim	1	7	0	0
24	Tamil Nadu	5	21	1	0
25	Tripura	2	4	0	0

26	Uttar Pradesh	1	23	0	0
27	Uttaranchal	6	6	2	0
28	West Bengal	5	15	0	0
29	Andaman & Nicobar	9	96	0	0
30	Chandigarh	0	2	0	0
31	Dadar & Nagar Haweli	0	1	0	0
32	Lakshadweep	0	1	0	0
33	Daman & Diu	0	1	0	0
34	Delhi	0	1	0	0
35	Pondicherry	0	1	0	0
	TOTAL	**102**	**515**	**47**	**4**

(Source:http://www.moef.nic.in/downloads/public-information/protected-area-network.pdf).

Table-2: List of Biosphere Reserves, their area and location

S.No.	Name of the Biosphere Reserve & total geographical area (Km^2)	Location in the State (s)/Union Territory
1	Nilgiri (5520)	Part of Wynad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani hills in Tamil Nadu, Kerala and Karnataka.
2	Nanda Devi (5860.69)	Part of Chamoli, Pithoragarh and Almora districts in Uttarakhand.
3	Nokrek (820)	Part of East, West and South Garo Hill districts in Meghalaya.
4	Manas (2837)	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup and Darang districts in Assam.
5	Sunderban (9630)	Part of delta of Ganges & Brahamaputra river system in West Bengal.
6	Gulf of Mannar (10500)	India part of Gulf of Mannar extending from Rameswaram island in the North to Kanyakumari in the South of Tamil Nadu.
7	Great Nicobar (885)	Southern most island of Andaman and Nicobar Islands.
8	Similipal (4374)	Part of Mayurbhanj district in Orissa.
9	Dibru-Saikhova (765)	Part of Dibrugarh and Tinsukia districts in Assam.
10	Dehang-Dibang (5111.5)	Part of Upper Siang, West Siang and Dibang Valley districts in Arunachal Pradesh.
11	Pachmarhi (4981.72)	Part of Betul, Hoshangabad and Chhindwara districts in Madhya Pradesh.
12	Khangchendzonga (2931.12)	Part of North and West districts in Sikkim.
13	Agasthyamalai (3500.36)	Part of Thirunelveli and Kanyakumari districts in Tamil Nadu and Thiruvanthapuram, Kollam and Pathanmthitta districts in Kerala.

14	Achanakmar- Amarkantak (3,835. 51)	Part of Anuppur and Dindori districts of Madhya Pradesh and Bilaspur district of Chattisgarh.
15	Kachchh (12,454)	Part of Kachchh, Rajkot, Surendranagar and Patan districts in Gujarat.
16	Cold Desert (7,770)	Pin Valley National Park and surroundings; Chandratal & Sarchu; and Kibber Wildlife sanctuary in Himachal Pradesh.
17	Seshachalam (4755.997)	Seshachalam hill ranges in Eastern Ghats encompassing part of Chittoor and Kadapa districts in Andhra Pradesh.
18	Panna (2998.98)	Part of Panna and Chhattarpur districts in Madhya Pradesh

8.3.2-Ex-situ conservation

The ex-situ conservation approaches require collection and systematic long term storage of germ plasm outside the natural habitats of species. Normally, the following components constitute the ex-situ conservation sites.

1. Seed banks maintained at sub-freezing temperature (-20^{0}C),
2. Cryobanks under liquid nitrogen (-165 to -196^{0}C),
3. In-vitro tissue culture banks at varying degrees of temperature regimes (4 to 25^{0}C) and sub-culture intervals (4-24 months) depending upon individual species, DNA Banks,
4. Filed repositories,
5. Botanical Gardens,
6. Arboreta etc.

Ex-situ conservation measures can be complementary to in-situ methods as they provide an "insurance policy" against extinction. These measures also have a valuable role to play in recovery programmes for endangered species. The Kew Seed Bank in England has 1.5 per cent of the world's flora - about 4,000 species - on deposit (Source: http://www.jamaicachm.org.jm/BHS/conservation.htm)

Ex-situ conservation provides excellent research opportunities on the components of biological diversity. Some of these institutions also play a central role in public education and awareness raising by bringing members of the public into contact with plants and animals they may not normally come in contact with. It is estimated that worldwide, over 600 million people visit zoos every year.

8.4 GENE BANK

Conserving the genetic diversity of our crops, landraces and related wild species is essential to ensure future plant breeders can access this variation, especially in view of increased food demand by a growing world population and climate change.

Gene banks are repositories where biological material is collected, stored, catalogued and made available for redistribution. The main role of gene banks is to preserve genetic diversity, in the form of seeds or cuttings in the case of plants reproduced vegetatively, and subsequently make this material, together with associated information, available for future use in research and plant breeding.

Gene banks are sometimes also referred to as an ex-situ conservation facility (because biological materials are conserved outside their natural habitat). An important part of the work at gene banks is to ensure the seed collection remains alive: seeds need to be periodically checked for viability and the material regenerated to replenish the collection with fresh seed and planting materials.

Gene bank- guidelines

By now it is clear that conservation of genetic recourses is a high priority in the national or international context, as a global plan of action activity or a convention on biological diversity requirement. The National Plant Genetic Resources Programme in India has already developed elaborate guidelines for sending germplasm for long-term conservation in its gene bank, which maintains international standards and also ensure long term viability of the material conserved after due processing. It has been suggested that the following points should be check-listed after sending seeds for ex-situ conservation. The seed should be:

a. well developed and physiologically mature,
b. free from insects, weeds and disease,
c. clean and free from undesired, shriveled, immature and discolored seeds,
d. properly labeled and packed to avoid damage during transit,
e. untreated with chemicals,
f. sent to Genebank at the earliest possible (soon after harvest),
g. accompanied with minimum passport data such as name of crop, location of collection, its original identification number/name, evaluation data, other special attributes (diseases/stress resistance quality), month and year of seed harvest etc. and
h. sent in sufficient numbers.

Primarily it is suggested that the sample should contain at least 3000 seeds for conservation in case of self-pollinated crop species, which are genetically homogenous and how little morphological variation. On the other hand, 6000 seeds of cross pollinated crop species, being genetically heterogeneous, should be provided so as to give an adequate representative outlook to the accession in respect of its original population, including morphological variation of the seed lot. Seeds of landraces, wild or weedy forms and rare plant species may be provided in smaller quantities depending upon availability.

Plant genetic resource conservation in gene banks and the Indian Status

Over 2.7 million crop accessions are held in germplasm collections globally, including over 1.3 million accessions of cereals 3, 70,000 accessions of food legumes; 2,20,000 accessions of forage legumes and grasses; 1,38,000 accessions of vegetables and 74, 000 clones of root crops. Crops of major economic importance that are backed by Agricultural Research Programmes are best represented in gene banks. Keeping in view the national needs, the

Department of Agricultural Research and Education and Indian Council of Agricultural Research has provided umbrella to the ex-situ and on-farm conservation of biodiversity especially agro-biodiversity. Germplasm holding of various crop plant species at different IARCs and some National gene banks are presented in Table 3 and germ plasm of Indian originated stored in different international gene banks are presented in Table 4 and 5.

Table-3: Germ Germplasm holding of various crop plant species at different IARCs and some National gene banks

Institute/Country/Gene Bank	Holdings	Institute/Country/Gene Bank	Holdings
Wheat VIR	74500	Chickpea IRCRISAT	14361
USDA	39000	ICARDA	5585
CIMMYT	31144	USA	3396
Italy	26000	India	2000
Rice IRRI	82000	Groundnut ICRISAT	11641
NSSL (USA)	18063	INDIA	6274
USDA	11230	POTATO VIR	9435
INDIA MAIZE VIR	19858	CIP	6500
CIMMYT	12500	USA	2375
NSSL (USA)	12500	INDIA MUNGBEAN	5483
YUGOSLAVIA	8000	CHINA	5483
INDIA UPLB LOS BANOS, PHILIPPINES	2500	INDIA	1850; 5736

Source: (*Gautam et al*., 1998)

Table-4: Germplasm of Indian-origin conserved in CGIAR gene-banks

S. No.	CGIAR Genebank	Total no. of accessions	Accessions of Indian origin	
			No.	%
1	International Crop Research Institute for the Semi-Arid Tropics, India	119,524	37,470	35.54
2	International Rice Research Institute, The Philippines	131,862	17,824	16.81
3	International Centre for Agricultural Research in Dry Areas, Syria	147,118	3,747	3.53
4	International Institute of Tropical Agriculture, Nigeria	27,232	2,276	8.36
5	International Livestock Research Institute, Ethiopia	20,229	501	2.48
6	Centro Internacional de Agricultura Tropical, Colombia	64,721	422	0.65
7	Centro Internacional de Mejoramiento de Maíz y Trigo, Mexico	164,320	318	0.19
8	West African Rice Development	26,098	299	1.15

S. No.	CGIAR Genebank	Total no. of accessions	Accessions of Indian origin	
			No.	%
	Association, Ivory Coast			
9	**Musa** International Transit Centre, Diversity International, Belgium	1,529	54	3.53
10	Centro Internacional de la Papa, Peru	16,061	9	0.06
11	Information and Communication Division, International Center for Research in Agroforestry, Kenya	2,005	0	0
	Total	**720,699**	**62,920**	**8.73**

Table-5: **Germplasm of Indian-origin conserved in major national gene-banks**

S. No.	International Genebank	Total no. of accessions	Accessions of Indian-origin	
			No.	%
1	USDA Genebanks, USA	625,112	22,582	3.61
2	N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, Russia	346,415	8,145	2.35
3	Asian Vegetable Research and Development Center, Taiwan	60,883	4,729	7.77
4	Leibniz Institute of Plant Genetics and Crop Plant Research, Germany	137,010	2,233	1.63
5	Department of Applied Genetics, John Innes Centre, Norwich Research Park, UK	26,669	1,714	6.43
6	Plant Breeding and Acclimatization Institute, Poland	67,980	428	0.62
7	Millennium Seed Bank Project, Seed Conservation Department, Royal Botanic Garden, Kew, UK	46,689	335	0.72
8	Division of Genetics and Plant Breeding, Research Institute of Crop Production, Czech Republic			

(**Source**: Indian Plant Germplasm on the Global Platter: An Analysis Sherry R. Jacob,[1] Vandana Tyagi,[2] Anuradha Agrawal,[3] Shyamal K. Chakrabarty,[4] and Rishi K. Tyagi[1,*] LoS One. 2015; 10(5): e0126634. Published online 2015 May 14.doi: 10.1371/journal.pone.0126634.)

8.5 NATIONAL BUREAU OF PLANT GENETIC RESOURCES

History

Indian interest and abiding concern in the collection and utilization of plant genetic resources dates back to the early decades of this century (Howard and Howard, 1910), though botanical accounts on available flora and the economic plants/products had been documented much earlier (Hooker, 1872-97; Watt, 1889-93). However, it was late Dr. B.P. Pal who truly focused attention on the use of germplasm variability in crop improvement in national context. The publication of his paper, ‘The search for new genes', in fact, paved the way for augmenting genetic diversity for use in plant breeding (Pal, 1937; Pal and Singh, 1943). It was primarily due to his foresight and wisdom that a nucleus Plant Exploration and Collection Unit was established in 1946 in the Division of Botany at the Indian Agricultural Research Institute, New Delhi. This unit became a regular wing in 1956 that was raised to the status of a Division of Plant Introduction in 1961. The late Dr. Harbhajan Singh dedicated his entire services to operate and boost these activities from the beginning and particularly so during the 1960s-1970s. (Singh and Hardas, 1970; Singh, 1970). Dr. M.S. Swaminathan and Dr. A.B. Joshi further strengthened the foundations of these activities. To serve the needs of the ICAR Crop Research Institutes, All India Coordinated Crop Improvement Projects and State Agricultural Universities, the Indian Council of Agricultural Research created a separate organization named as National Bureau of Plant Genetic Resources (NBPGR) in 1976 along with two other Bureaus concerned with animal and fish genetic resources.

NBGPR and its activities

NBPGR's activities have grown rapidly since 1976. It is a service-oriented national institute with a component of basic research for improving quality and efficiency of its services. It has five major Divisions, namely, Division of Plant Exploration and Collection, Division of Germplasm Exchange, Division of Plant Quarantine, Division of Germplasm Evaluation and Division of Germplasm Conservation. In addition, there is a DBT funded National Facility for Plant Tissue Culture Repository. The Bureau also has 12 Regional Stations/Base Centres/Quarantine Stations/Experimental Farms located in different agro-climatic zones. In addition, several All India Coordinated Crop Improvement Projects on Medicinal and Aromatic Plants, cluster bean, and under-utilized and under-exploited plants are also located at the Bureau. Primary objectives of the Bureau are to:

1. Organize and conduct plant exploration and germplasm collection activities in India and abroad.
2. Undertake and coordinate the supply/introduction/exchange of plant genetic resources for research purpose within India and abroad.
3. Conduct plant quarantine examination of plant materials introduced by the Bureau for pests and pathogens; treat and salvage infested/infected material and carry out research on plant quarantine/seed-health problems.
4. Conduct, monitor and coordinate all activities concerning germplasm conservation in national base and active collections.

5. Characterize, evaluate and document available germplasm collections and coordinate these activities at the Regional Stations and other collaborating Institutes with a view to preparing proper inventories and catalogues of such resources.
6. Develop and operate the National PGR Database for documentation and retrieval of information on plant genetic resources held by the Bureau and all other collaborating institutes/centres.
7. Conduct training programmes on different aspects of genetic resources activities at national and international levels.
8. Develop and implement work-plans concerning PGR activities based on memoranda of understanding under bilateral and international agreements.

In order to fulfill its national mandate, the Bureau maintains links with all crop-based institutes/national research centres of the Indian Council of Agricultural Research, State Agricultural Universities and the network of All India Co-ordinated Crop Improvement Projects. In addition, the Bureau maintains effective links with more than seventy countries as well as different crop-based international institutes under the CGIAR system including, the IBPGR.

The Exploration Division of NBPGR develops advance perspective plans for germplasm collection in collaboration with other cooperating institutes/centres. More than 80,000 accessions of indigenous cultivars and their wild relatives have already been collected through over 300 crop-specific and region-specific explorations (Table 6). These represent wide variability in crops like wheat, maize, rice, minor millets, cucurbits, okra, eggplant, tuber crops, jute, cotton, ginger, sugarcane, mango, banana, jujube, citrus, black pepper, turmeric, medicinal plants and forages, besides many others. The areas already explored include the North-eastern region, North-Western Himalayas, drier western plains, central India and the eastern and western peninsular tracts. Indigenous collections have been further enriched by importing over 9, 00,000 samples from more than 70 countries through specific requests and exchange (Table 7). Diverse germplasm has thus been introduced from different international crop-based institutes/centres like IRRI, Philippines; CIMMYT, Mexico; ICARDA, Syria; CIP, Peru; CSIRO, Australia; VIR, USSR; USDA, USA; AVRDC, Taiwan; INTSOY, USA; ICRISAT, India, besides, the FAO and IBPGR.

Table-6: Germplasm collecting activities at NBPGR

Year	**No. of explorations undertaken**	**No. of germplasm samples collected**		
		Cultivated	**Wild**	**Total**
1976	4	1,987	138	2,125
1977	6	5,099	24	5,123
1978	7	938	11	949
1979	11	4,256	54	4,310
1980	7	4,559	22	4,581
1981	16	6,031	271	6,302
1982	9	3,575	-	3,575

1983	9	3,000	-	3,000
1984	10	3,525	-	3,525
1985	25	8,008	55	8,063
1986	43	8,391	97	8,488
1987	44	7,115	178	7,293
1988	52	7,646	154	7,800
1989	59	11,278	925	12,203
1990	42	5,071	751	5,822
Total	**344**	**80,479**	**2680**	**83,159**

Table-7: Exchange of plant germplasm

Year	No. of samples		National supply
	Import	Export	
1976	85,872	70,551	3,284
1977	74,835	10,686	2,397
1978	1,17,279	8,697	2,059
1979	1,30,194	5,287	2,976
1980	51,906	1,917	6,558
1981	53,264	2,260	6,889
1982	42,663	1,748	5,681
1983	49,268	2,683	6,213
1984	38,992	3,843	3,701
1985	85,117	1,355	5,867
1986	52,767	5,535	12,726
1987	52,642	2,260	10,578
1988	53,629	2,168	11,828
1989	50,536	3,310	17,250
1990	49,521	1,195	12,680
Total	**9,88485**	**1,23,495**	**1,10,687**

Plant quarantine facility at the Bureau has helped in ensuring that insect pests, pathogens and obnoxious weeds do not enter the country along with seed and other propagating materials. Well equipped laboratories of Plant Pathology, Virology, Nematology and Entomology work hand-in-hand to salvage the infected/infested materials using techniques, such as mechanical cleaning, washing, fumigation, X-ray radiography, hot water treatment, acid seed treatment, pesticidal seed treatment, dips and sprays, etc. A large number of important exotic plant pests, nematodes and pathogens have been intercepted. A recent case is that of the groundnut stripe virus intercepted by the Hyderabad Station of NBPGR in collaboration with ICRISAT.

The Seed Repository of the National Gene Bank at NBPGR Headquarters, New Delhi, conserves genetic resources of orthodox (desiccation-tolerant) agri-horticultural crop plants in the form of seed under controlled conditions of temperature and seed moisture. Two types of cold storage vaults are available: (i) medium-term storage facility kept at + 4° C and 35 percent RH, and (ii) long-term storage vaults (2 units of 100 m^2 each and 2 of 176 m^2 each) maintained at-20° C. The repository has a fully equipped seed testing laboratory and other ancillary facilities. Over 1, 35, 000 accessions of various crop plants are currently stored in the repository (Table 8) and its present storage capacity is about two lakh (0.2 million) accessions. Protocols have also been developed for making the plant germplasm collections disease-free through tissue culture techniques and ensuring their safety under *in-vitro* storage. Work has been in progress on crops, such as yams, *Coleus,* ginger, *Musa* and citrus. Experimental work has also progressed for storing seeds at -196°C in cryopreservation tanks using liquid nitrogen.

Table-8: National gene bank in operation at NBPGR (germplasm kept in long-term storage

Crop groups	No. of accessions
Cereals	34,697
Pulses	21,510
Millets and minor millets	12,850
Oilseeds	12,621
Vegetables	3,635
Fibre crops	2,609
Narcotics	665
Medicinal and aromatic plants	138
Pseudo cereals (miscellaneous crops)	653
Improved (named) varieties	302
Voucher specimens of exotics	19,178
Reference samples of indigenous collection	27,000
Total holdings	**1,35,858**

The Bureau is also the lead institute to impart training in all facets of PGR activities. It has organized international/regional training programmes for the South and South-East Asia region with IBPGR support. It has also conducted regular short duration trainings at the national level and a Summer Institute sponsored by ICAR. This activity has been further accelerated now (from 1990) with national training programmes conducted by NBPGR in plant exploration and collection, tissue culture and cryopreservation techniques, medium and long-term storage of seed materials, exchange of germplasm and plant quarantine methods, and computer appreciation related to PGR documentation. The emphasis is on training of the concerned PGR scientists from ICAR crop institutes and other interested research centres in public institutions and universities with a view to producing more resource personnel in this field. The NBPGR is also the information dissemination organization on PGR activities. It regularly publishes Research Highlights, Annual Reports, Newsletter (quarterly) and the Plant Introduction Reporter (quarterly). It has so far published well over 400 research papers, reports, brochures, bulletins, inventories, catalogues, books, proceedings of seminar/ symposia, etc. with bearing on conservation and scientific management of plant genetic resources. This has helped in creating awareness and know-how among the scientific community as well as public and private organizations. The list of active germ plams collections at NGPGR is presented in table 9.

Table-9: Active germplasm collections at NBPGR

Station/Centre	Holdings	Major Crops
Delhi	38,708	Cereals, legumes, oilseeds, vegetables, forages, fruits
Akola	39,004	Chickpea, pigeon pea, sorghum, groundnut, small millets, soybean, safflower, sesame, lentil, amaranths, horse gram.
Amravati	5,800	Mung bean, rice bean, urid bean, sweet potato, chillies, onion, garlic, fruits (grapes, pomegranate, papaya).
Shimla	13,105	French bean, rice bean, soybean, lentil, Minor millets, pseudo-cereals, oilseeds, temperate fruits, ornamentals.
Jodhpur	12,076	Guar, moth bean, mung bean, sesame, cowpea, castor
Trichur	8,936	Paddy, horsegram, cowpea, finger millet, chillies, bittergourd, ginger, *Curcuma, Colocasia*, cassava, *Dioscorea.*
Bhowali	5,894	Wheat, maize, barley, lentil, beans, hill paddy, *Allium* spp.
Cuttack	1,943	Rices
Shillong	1,733	Hill rices, maize, rice bean, root crops, fruits.

8.6 SUMMARY

This Module provides comprehensive information about need of the conservation and also tries to explain why conservation of biodiversity is necessary. Explanatory notes on the various conservation methods like ex-situ and in-situ were also discussed in details along with the examples of the said methods (In-situ: National Parks, Wildlife Sanctuaries, Biosphere Reserves, Conservation Reserve and Community Reserves and Ex-situ: Seed Banks, Cryobanks, Field repositories, Botanical Gardens, and Arboreta along with suitable definitions and list of all categories). It also helps to understand the concepts behind Protected Areas Network and its different categories. In this module attempt was also made to discuss history of Plant Genetic Resources and details in different Gene Banks and the responsibilities of the organizations involved in such types of work. Further, this module also discussed history; role and importance of National Bureau of Plant Genetic Resources (a nodal agency of conservation in India).

8.7 GLOSSARY

AVRDC: The World Vegetable Centre
CGIAR: Consultative Group for International Agricultural Research
CIMMYT: International Maize and Wheat Improvement Center
CIP: International Potato Center
CSIRO: The Commonwealth Scientific and Industrial Research Organization
DBT: Department of Biotechnology
DNA: Deoxyribonucleic Acid
FAO: Food and Agriculture Organization
IBPGR: International Board for Plant Genetic Resources
ICAR: Indian Council of Agricultural Research
ICARDA: The International Center for Agriculture Research in the Dry Areas
ICRISAT: The International Crops Research Institute for the Semi-Arid Tropics
IRRI: International Rice Research Institute
NBPGR: National Bureau of Plant Genetic Resources
NDRI: National Dairy Research Institute
PGR: Plant Genetic Resources

8.8 SELF ASSESSMENT QUESTIONS

8.8.1 Multiple Choice Questions

1- ………………… is most common example of the In-situ conservation.
(i) National Park (ii) Gene Bank
(iii) Botanical Garden (iv) Seed Banks

2- Sunderban is situated in ………………………
(i) Uttarakhand (ii) Eastern Ghats
(iii) Delta of Ganges and Brahamaputra (iv) Sikkim

3- Dibur-Saikhova is the ………………………. Biosphere Reserve.
(i) Smallest (ii) Largest
(iii) Both i & ii. (iv) None of the above

4- Head office of the NBPGR is located at …………………
(i) New Delhi (ii) Mumbai
(iii) Kolkatta (iv) Dehra Dun

5- Core and Buffer zones are important constituents of ………………
(i) Biosphere Reserve (ii) Wild Life Sanctuary
(iii) Community Reserve (iv) Arboreta

6- …………….. will be the best conservation approach.
(i) In-situ followed by ex-situ (ii) Ex-situ followed by In-situ
(iii) Both (iv) None of the above

7- Nanda Devi Biosphere Reserve is located in………………………. state.
(i) Himachal Pradesh (ii) Jammu and Kashmir
(iii) Uttarakhand (iv) Sikkim

8.8.1 Answers Key: 1-(i); 2-(iii); 3-(i); 4-(i); 5-(i); 6-(ii); 7- (iii)

8.9 REFERENCES

- Rio de Janeiro. (1992). Documents from the United Nations Conference on Environment and Development (also known as UNCED or the Earth Summit).
- Gautam P. L., Mithal S. K. and Kochhar S. (1998). Wheat genetic resources management and its use in National PGR system. In: Wheat: Research Needs Beyond 2000 AD. (eds.) Nagarajan S., Singh G. & Tyagi B. S. Narosa Publishing House, N. Delhi, pp. 3.
- Howard, A. and G.L.C. Howard. (1910). Wheat in India - Its production, varieties and improvement. Thacker Spinn and Co., Calcutta.
- Hooker, J.D. (1872-97). The Flora of British India. (7 vols.). London.
- Watt, G. (1889-93). A Dictionary of Economic Products of India (6 vols.). London.
- Pal, B.P. (1937). The search for new genes. Agriculture and livestock in India. 7:573-578.
- Pal, B.P. and H.B. Singh. (1943). A note on the economic possibilities of the cross *Lycopersicum esculentum* × *L. pimpinellifolium.* Indian J. Genetics. 3: 115 - 120.
- Singh, H.B. and M. W. Hardas. (1970). Plant Introduction. Agricultural Year Book. ICAR, New Delhi.
- Singh, H.B. (1970). Far East Asia, India, in survey of crop genetic resources in their centres of diversity First report, (Ed., O.H. Frankel). FAO/IBP, Rome, Italy.

8.10 SUGGESTED READINGS

- Singh, B.P. and Srivastava, U. (2013). Plant Genetic Resources in Indian Perspective: Theory and Practices. ICAR Publication.
- Upadhyaya, H.D., Gowda, C.L.L. and Sastry, D.V.S.S.R. (2008). Plant genetic resources management: collection, characterization, conservation and utilization. An Open Access Journal published by ICRISAT.
- Bioversity International and Rural Development Administration. (2009). A Training Module for the International Course on Plant Genetic Resources and Genebank Management. Bioversity International, Rome, Italy.
- A global overview of protected areas on the world heritage list of particular importance for biodiversity. UNEP World Conservation Monitoring Centre Cambridge, UK. (2000).

8.11 TERMINAL QUESTIONS

1. "Bio-diversity is the fundamental to the existence of life on the earth" Justify the statement by giving any two reasons.
2. State different objectives for establishment of Protected Areas Network in India.
3. Discuss the role of NBPGR in conserving the germplasm.
4. Discuss in brief various methods involved in the conservation of biodiversity with suitable examples.
5. What are the two biodiversity conservation measures? Explain.
6. How can you contribute to the conservation of green wealth of your locality? Make a list of actions to be taken by you.
7. In what ways in-situ conservation differs from ex-situ conservation. Justify your answer with quoting some suitable examples.

UNIT-9 BIODIVERSITY- HOTSPOTS AND MEGA BIODIVERSITY COUNTRIES

Contents

9.1 OBJECTIVES

After reading this unit students will be able-

- To provide an overview of Hotspots and concept behind the creation of Hot spots
- To provide the comprehensive information about the Global biodiversity hotspots and Mega-biodiversity countries
- To provide information regarding India as mega-biodiversity country

9.2 INTRODUCTION

As demonstrated by several researches, maintaining biodiversity is essential to the supply of ecosystem services and not less important to support their health and resilience (Pereira et al., 2013). However, despite there being an international interest to sustain and protect biodiversity, its loss does not seem to slow down (Butchart et al., 2010). Although there has been an extension of protected areas (Pimm et al., 2014), these provide a still low species coverage (Venter et al., 2014) and do not appear to optimally protect biodiversity (Pimm et al., 2014). For instance, a recent analysis (Selig et al., 2014) for conservation priorities in marine environments by combining spatial distribution data for nearly 12,500 species with human impacts information, identified new areas of high conservation value that are located in Arctic and Antarctic Oceans and beyond national jurisdictions. Overall, habitat change and their over-exploitation, pollution, invasive species and in particular climate change are the major causes for biodiversity loss. The combined effect of these anthropogenic pressures may have already started a critical transition toward a tipping point (Barnosky et al., 2012). In particular, climate is modifying rapidly forcing biodiversity to adapt either through the change of habitat and life cycles or the development of new physical traits (Berteaux et al., 2010). For instance, rising temperatures can lead to potential biodiversity increases in northern regions (i.e. northern biodiversity paradox) where low temperatures usually are a limiting factor for the establishment of many species (Berteaux et al., 2010). Given the importance that biodiversity plays, the understanding of the main threats to biodiversity is today than ever before a central objective in conservation biology. Nowadays there is serious concern about the effectiveness of existing strategies for biodiversity protection. A central issue in conservation is to identify biodiversity-rich areas to which conservation resources should be directed. Based on the observation that some parts of the world have far more species than others, the area-based approaches are widely advocated for species conservation planning. Areas with high concentrations of endemic species (species that are found nowhere else on Earth) and with high habitat loss are often referred to as ‘‘hotspots’’ (Myers, 1988). The hotspot approach can be applied at any geographical scale and both in terrestrial and marine environments. However, hotspots represent conservation priorities in terrestrial ecosystems but remain largely unexplored in marine habitats (Worm et al., 2003) where the amount of data is still poor (Mittermeier et al., 2011). Despite this lack of homogeneity in data between terrestrial and aquatic ecosystems, the recent concerns over loss of biodiversity have led to calls for the preservation of hotspots as a priority. Edward O. Wilson, one of the leading authorities on conservation, described the hotspot approach as ‘the most important contribution to conservation biology of the last century. Closely linked to the concept of biodiversity, the hotspot concept is used with increasing frequency in biology and conservation literature and often with different meanings. While in a strict sense, the meaning is based on an estimate of endemic species and habitat loss, in a broad sense it refers to any area or region with exceptionally high biodiversity at the ecosystem, species and genetic levels.

Biodiversity hotspots concept

The British ecologist Norman Myers first published the biodiversity hotspot thesis in 1988. Myers, although without quantitative criteria but relying solely on the high levels of habitat loss and the presence of an extraordinary number of plant endemism, identified ten tropical forest as ‘‘hotspots’’ (Mittermeier et al., 2011). A subsequent analysis (Myers, 1990) added a further eight hotspots, including four in Mediterranean region. Conservation International (CI—http://www.conservation.org) adopted Myers’ hotspots as its institutional blueprint in 1989, and afterwards worked with him in a first systematic update of the global hotspots. Myers, Conservation International, and collaborators later revised estimates of remaining primary habitat and defined the hotspots formally as biogeographic regions with >1500 endemic vascular plant species and ≤30% of original primary habitat (Myers et al., 2000). This collaboration, which led to an extensive global review (Mittermeier et al., 1999) and a scientific publication (Myers et al., 2000) saw the hotspots expand in area as well as in number, on the basis of both the better-defined criteria and new data. A second major revision and update in 2004 (Mittermeier et al., 2004) did not change the criteria but by redefining several hotspots boundaries, and by adding new ones that were suspected hotspots for which sufficient data either did not exist or were not easily accessible, brought the total to 34 biodiversity hotspots (Mittermeier et al., 2011). Recently, a 35th hotspot was added (Williams et al., 2011), the Forests of East Australia.

Hotspots identification

Biodiversity hotspots are particular areas where extraordinary concentrations of biodiversity exist. Although hotspots have also been identified through different ways (Hoekstra et al., 2005), these areas are usually defined by one or more species-based metrics (number of species – species richness; number of species restricted to a particular area – endemic species richness; and number of rare or threatened species) or focusing on phylogenetic and functional diversity in order to protect species that support unique and irreplaceable roles within the ecosystem.

9.3 GLOBAL BIODIVERSITY HOTSPOTS

Globally, at as present the 35 biodiversity hotspots (Table 1) that cover only 17.3% of the Earth’s land surface are characterized by both exceptional biodiversity and considerable habitat loss (Myers et al., 2000). More precisely, hotspots maintain 77% of all endemic plant species, 43% of vertebrates (including 60% of threatened mammals and birds), and 80% of all threatened amphibians (Mittermeier et al., 2011; Williams et al., 2011).

Table-1 Biodiversity hotspots from 1988 to present

Source: Modified from: Mittermeier et al. (2011).

Myers (1988) Revision	**Myers (1990)**	**Myers et al. (2000)**	**Mittermeier et al. (2004)**	**2011**
Uplands of Western	Uplands of Western			
Amazonia	Amazonia	Tropical Andes[a]	Tropical Andes	Tropical
Andes				
Western Ecuador	Western Ecuador			
Colombian Choco	Colombian Choco	Choco/Darien/western	Tumbes-Choco-Magdalena	Tumbes-
Choco-				
		Ecuador[b]		
				Magdal
ena				
Atlantic Coast Brazil	Atlantic Coast Brazil	Atlantic Coast Brazil	Atlantic Forest	Atlantic
Forest				
		Brazilian Cerrado	Cerrado	Cerrado
	Central Chile	Central Chile[a]	Chilean Winter Rainfall and	Chilean Winter
Rainfall				
			Valdivian Forest	and Valdivian
		Forest		
		Mesoamerica	Mesoamerica	
			Mesoamerica	
			Madrean Pine-Oak	Madrean
			Pine-Oak	
			Woodlands	
				Woodla
			nds	
		Caribbean	Caribbean Islands	Caribbean
	Islands			
	California Floristic Province	California Floristic	California Floristic Province	California
Floristic				
		Province		
				Provi
	nce			
	Ivory Coast	Guinean Forest of West	Guinean Forest of West	Guinean Forest of
West				
		Africa[a]	Africa	
			Africa	
	Cape Floristic Region	Cape Floristic Province	Cape Floristic Region	Cape Floristic
Region				
		Succulent Karoo	Succulent Karoo	Succulent
Karoo				
			Maputaland-Pondoland-	Maputaland-
			Pondoland-	
			Albany	
				Alb
			any	
	Tanzania	Eastern Arc and Coastal	Eastern Afromontane[d]	Eastern
Afromontane Forest of				
		Tanzania/		
		Kenya		
			Coastal Forests of Eastern	Coastal Forests of
			Eastern	
			Africa[d]	
				Af
			rica	
			Horn of Africa	Horn of
			Africa	
Eastern Madagascar	Eastern Madagascar	Madagascar and Indian	Madagascar and Indian	Madagascar and
Indian				
		Ocean Islands	Ocean Islands	Ocean
		Islands		
		Mediterranean Basin	Mediterranean Basin	Mediterranean
		Basin		
		Caucasus	Caucasus	
			Caucasus	
			Irano-Anatolian	Irano-
			Anatolian	
			Mountains of Central Asia	Mountains of
			Central Asia	
	Western Ghats in India			
	Southwestern Sri Lanka	Western Ghats and Sri	Western Ghats and Sri	Western Ghats

	and Sri			
		Lanka[b]	Lanka	
			Lanka	
		Mountains of	Mountains of	South-Central
			Mountains of	
		South-Central China	China	South-Central
		China		
			Indo-Burma	Indo-
Burma				
Eastern Himalayas	Eastern Himalayas	Indo-Burma[e]	Himalaya[f]	
	Himalaya			
Peninsular Malaysia	Peninsular Malaysia			
Northern Borneo	Northern Borneo	Sundaland[b]	Sundaland	
	Sundaland			
		Wallacea	Wallacea	
			Wallacea	
Philippines	Philippines	Philippines	Philippines	
	Philippines			
			Japan	Japan
	Southwest Australia	Southwest Australia[a]	Southwest Australia	Southwest
Australia				
				Forests of East
			Australia[g]	
			East Melanesian Islands	East Melanesian
		Islands		
		New Zeeland	New Zeeland	New
Zeeland				
New Caledonia	New Caledonia	New Caledonia	New Caledonia	New
Caledonia				
		Polynesia-Micronesia	Polynesia-Micronesia	Polynesia-
Micronesia				

a) Expanded.
b) Merged and/or expanded.
c) Expanded to include Coastal Forests of Tanzania and parts of Kenya.
d) The Eastern Arc and Coastal Forests of Tanzania/Kenya hotspots was split into the Eastern Afromontane hotspot (the Eastern Arc Mountains and Southern Rift, the Albertine Rift, and the Ethiopian Highlands) and Coastal Forests of Eastern Africa (southern Somalia south through Kenya, Tanzania and Mozambique).
e) Eastern Himalayas was divided into Mountains of South-Central China and Indo-Burma, the latter of which was expanded.
f) The Indo-Burma hotspot was redefined and the Himalayan chain was separated as a new Himalayan hotspot, which was expanded. g The Forests of Eastern Australia the 35th biodiversity hotspot.

9.4 MEGABIODIVERSITY COUNTRIES

As we have already discussed with you that as at present we have only 35 mega biodiversity hotspots in the world. For details please refer table 1 of this Unit.

9.5 INDIA AS MEGA-BIODIVERSITY COUNTRY

India is exceptionally rich in biodiversity and is one of the twelve mega diversity centres of the world. With 10 biogeographic zones and 25 biotic provinces, all major ecosystems are represented. India is a land mass of nearly 33 lakh sq km with a coastline of 7,616 km and 14 different types of climatic forests and the total forest coverage in India is about 6,50,000 sq km. The diverse physical features and climatic situations have formed ecological diverse habitats like forests, grasslands, wetlands, coastal and marine ecosystems and desert ecosystems, which harbor and sustain immense biodiversity. Biogeographically, India is situated at the tri-junction of three realms - Afro-tropical, Indo-Malayan and Paleo-Arctic realms, and therefore, has characteristic elements from each of them. This assemblage of three distinct realms makes the country rich and unique in biological diversity.

India is the home land of 13,000 species of flowering plants, 20,000 species of fungi, 50,000 species of insects, 65,000 species of fauna including 2000 species of birds, 350 mammals and 420 of reptiles. It covers nearly 7% of world’s flora and 6.5% of world’s fauna of which 33 % flora and 62% fauna are endemic. India has over 30 National parks that constitute about 1% of the landmass and 441 sanctuaries that constitute 3.5% of the area. India is a home of over 35,000 tigers and the umbrella of project tiger 23 specially demarcated project tiger reserves covering 33,000 sq.km representing different climatic forests are spread across the country. The country is also one of the 12 primary centres of origin of cultivated plants and domesticated animals. It is considered to be the homeland of 167 important plant species of cereals, millets, fruits, condiments, vegetables, pulses, fibre crops and oilseeds, and 114 breeds of domesticated animals.

India has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats from tropical rainforests to alpine vegetation and from temperate forests to coastal wetlands. **India figured with two hotspots** - the Western Ghats and the Eastern Himalayas - in an identification of 18 biodiversity hotspots carried out in the eighties. Recently, Norman Myers and a team of scientists have brought out an **updated list of 25 hotspots**. In the revised classification, the 2 hotspots that extend into India are The Western Ghats/Sri Lanka and the Indo-Burma region (covering the Eastern Himalayas); and they are included amongst the top eight most important hotspots. In addition**, India has 26 recognised endemic centres** that are home to nearly a third of all the flowering plants identified and described to date.

Of the estimated 5–50 million species of the world's biota, only 1.7 million have been described to date, and the distribution is highly uneven. About seven per cent of the world's total land area is home to half of the world’s species, with the tropics alone accounting for 5 million. India contributes significantly to this latitudinal biodiversity trend. With a mere 2.4% of the world's area, India accounts for 7.31% of the global faunal total with a faunal species count of 89,451 species. Some salient features of India's biodiversity have been mentioned below.

1. India has two major realms called the Palaearctic and the Indo-Malayan, and three biomass, namely the tropical humid forests, the tropical dry/deciduous forests, and the warm desert/semi-deserts.
2. India has ten biogeographic regions including the Trans-Himalayan, the Himalayan, the Indian desert, the semi-arid zone(s), the Western Ghats, the Deccan Peninsula, the Gangetic Plain, North-East India, and the islands and coasts.
3. As of date, there are 911 properties under the World Heritage List, which cover 711 cultural sites, 180 natural sites and 27 mixed properties encompassing 152 countries, including India. India is one of the 12 centres of origin of cultivated plants.

4. India’s first two sites inscribed on the list at the Seventh Session of the World Heritage held in 1983 were the Agra Fort and the Ajanta Caves. Over the years, 27 more sites have been inscribed, the latest site inscribed in 2012 being the Western Ghats. Of these 29 sites, 23 are cultural sites and the other six are natural sites. A tentative list of further sites/properties submitted by India for recognition includes 33 sites.
5. India has 17 biosphere reserves, and 19 Ramsar wetlands. Amongst the protected areas, India has 102 national parks and 490 sanctuaries covering an area of 1.53 lakh sq km.
6. The wildlife sanctuaries in India are home to around two thousand different species of birds, 3500 species of mammals, nearly 30000 different kinds of insects and more than 15000 varieties of plants.

The endemism of Indian biodiversity is high. About 33% of the country's recorded flora are endemic to the country and are concentrated mainly in the North-East, Western Ghats, North-West Himalaya and the Andaman and Nicobar islands. Of the 49,219 plant species, 5150 are endemic and distributed into 141 genera under 47 families corresponding to about 30% of the world's recorded flora, which means 30% of the world's recorded flora are endemic to India. Of these endemic species, 3,500 are found in the Himalayas and adjoining regions and 1600 in the Western Ghats alone. About 62% of the known amphibian species are endemic with the majority occurring in the Western Ghats. Nearly 50% of the lizards of India are endemic with a high degree of endemicity in the Western Ghats. India is a centre of crop diversity - the homeland of 167 cultivated species and 320 wild relatives of crop plants.

Corals reefs in Indian waters surround the Andaman and Nicobar Islands, the Lakshadweep Islands, and the Gulf areas of Gujarat and Tamil Nadu. They are nearly as rich in species as tropical evergreen forests.

India's record in agro-biodiversity is equally impressive. There are 167 crop species and wild relatives. India is considered to be the centre of origin of 30,000-50,000 varieties of rice, pigeon-pea, mango, turmeric, ginger, sugarcane, gooseberries etc and ranks seventh in terms of contribution to world agriculture.
Conservation and sustainable use of biological resources based on local knowledge systems and practices is ingrained in Indian ethos. The country has a number of alternative medicines, like *Ayurveda*, *Unani*, *Siddha* and Homeopathic systems which are predominantly based on plant based raw materials in most of their preparations and formulations. Herbal preparations for various purposes including pharmaceutical and cosmetic purposes form part of the traditional biodiversity uses in India.

Role of Government agencies for conserving the mega biodiversity of the country

About 4,900 species of flowering plants are endemic to the country. These are distributed among 141 genera belonging to 47 families. These are concentrated in the floristically rich areas of North-East India, the Western Ghats, North-West Himalayas and the Andaman and Nicobar Islands. These areas constitute two of the 18 hot spots identified in the world. It is estimated that 62 percent of the known amphibian species are endemic to India of which a majority is found in Western Ghats. Approximately 65 percent of the total geographical area has been surveyed so far. Based on this, over 46,000 species of plants and 81,000 species of animals have been described by the Botanical Survey of India (BSI) established in 1890 and Zoological Survey of India (ZSI) established in 1916, respectively. This list is being constantly upgraded, especially in lower plants and invertebrate animals. The Forest Survey of India established in 1981 assesses the forest cover with a view to develop an accurate database for planning and monitoring purposes.

The strategies for conservation and sustainable utilization of biodiversity have comprised providing special status and protection to biodiversity - rich areas by declaring them as National Parks, Wildlife Sanctuaries, Biosphere Reserves, Ecologically Fragile and Sensitive Areas. Other strategies include offloading pressure from Reserve Forests by alternative measures of fuel wood and fodder need satisfaction by afforestation of degraded areas and wastelands and creation of *ex-situ* conservation facilities such as Gene Banks. For example, the Tura Range in Garo Hills of Meghalaya is a gene sanctuary for preserving the rich native diversity of wild *Citrus* and *Musa* species.

Approximately, 4.2 percent of the total geographical area of the country has been earmarked for extensive *in-situ* conservation of habitats and ecosystems. A protected area network of 85 National Parks and 448 Wildlife Sanctuaries has been created. The results of this network have been significant in restoring viable population of large mammals such as tiger, lion, rhinoceros, crocodiles and elephants. The Indian Council of Forestry Research and Education (ICFRE) have identified 309 forest preservation plots of representative forest types for conservation of viable and representative areas of biodiversity. Out of these plots, 187 are in natural forests and 112 are in plantations, covering a total area of 8,500 hectares.

Recently a programme "Eco-development" for *in-situ* conservation of biological diversity involving local communities has also been initiated. The concept of eco-development integrates the ecological and economic parameters for sustained conservation of ecosystems by involving the local communities with the maintenance of earmarked regions surrounding protected areas. The economic needs of the local communities are taken care under this programme through provision of alternative sources of income and a steady availability of forest and related produce.

Further, several programmes have also been launched for scientific management and sustainable use of Wetlands, Mangroves and Coral reef ecosystems. Twenty one Wetlands, and Mangrove areas and 4 Coral reef areas have been identified for intensive conservation and management purposes. Six significant wetlands of India have been declared as "Ramsar Sites" under the Ramsar Convention. Under the World Heritage Convention, five natural sites have been declared as “WHS” such as NDBR in Uttarakhand.

To conserve the representative ecosystems, a Biosphere Reserve Programme is being implemented. Eighteen biodiversity rich areas of the country have been designated as Biosphere Reserves applying the UNESCO/MAB criteria. These reserves aim at conserving the biological diversity and genetic integrity of plants, animals and microorganisms in their totality as part of the natural ecosystems, so as to ensure that self-perpetuation and unhindered evolution of the living resources.

Government of India under the umbrella of Ministry of Environment and Forests constituted the National Afforestation and Eco-development Board (NAEB) in 1992 for promoting afforestation and management strategies which help the states in developing specific afforestation and management strategies and eco-development packages for augmenting biomass production through a participatory planning process of joint forest management and micro planning.

India is also a party to the Convention on Biological Diversity (CBD). The main objectives of this convention are; conservation of biological diversity, sustainable use of the components of biodiversity and fair and equitable sharing of benefits arising out of the utilization of genetic resources.

9.6 SUMMARY

Module started with the basic concepts of the hotspots and mega biodiversity countries. This also includes the need of the declaration regarding the designation/Identification of Hotspots. This also discussed Biodiversity Hotspot concept followed by Hotspots identification and Global Biodiversity Hotspots criteria. A comprehensive table consisting list of Biodiversity Hotspots from 1988 to present was also given to update the students. In the later section of module a case was presented to highlight India as a mega biodiversity country with all the facts and figures along with the role of Government agencies for conservation of the mega biodiversity of the country like Botanical Survey of India and Zoological Survey of India, Man and Biosphere Programme etc.

9.7 GLOSSARY

BSI: Botanical Survey of India
ZSI: Zoological Survey of India
ICFRE: Indian Council of Forestry Research and Education
UNESCO: The **United Nations Educational, Scientific and Cultural Organization**
MAB: Man and Biosphere Program
NAEB: National Afforestration and Eco-development Board
CBD: Convention on Biological Diversity
WHS: World Heritage Site
NDBR: Nanda Devi Biosphere Reserve

9.8 SELF ASSESSMENT QUESTIONS

9.8.1 Multiple Choice Questions

1. From the point of view of natural vegetation and wildlife, India belongs to which of the following categories?
(i) One of the twelve mega biodiversity countries of the world
(ii) The richest wildlife zone in the world
(iii) The country with the greatest forest cover
(iv) A country lacking in biodiversity cover

2. Who published the Biodiversity Hotspots Concept?
(i) Myers (ii) E.O. Wilson
(iii) E.P. Odum (iv)S.K.Jain

3. As at present how many Global Biodiversity Hotspots we have?
(i) 35 (ii) 40
(iii) 33 (iv) 34

4. India is one of the …………………… mega diversity countries.
(i) 15 (ii) 12
(iii) 11 (iv) 10

5. India is the home land of ……………………flowering plants.
(i) 13,000 (ii) 15,000
(iii) 70000 (iv) 5000

9.8.1 Answer Key: 1. (i); 2. (i); 3. (i); 4. (ii); 5. (i)

9.9 REFERENCES

- Barnosky, A.D., Hadly, E.A., Bascompte, J., Berlow, E.L., Brown, J.H., Fortelius, M., Getz, W.M., Harte, J., Hastings, A., Marquet, P.A., Martinez, N.D., Mooers, A., Roopnarine, P., Vermeij, G., Williams, J.W., Gillespie, R., Kitzes, J., Marshall, C., Matzke, N., Mindell, D.P., Revilla, E., Smith, A.B., 2012. Approaching a state shift in Earth's biosphere. Nature 486, 52–58.
- Berteaux, D., Blois, S.d., Angers, J.-F., Bonin, J., Casajus, N., Darveau, M., Fournier, F., Humphries, M.M., McGill, B., Larivée, J., Logan, T., Nantel, P., Périé, C., Poisson, F., Rodrigue, D., Rouleau, S., Siron, R., Thuiller, W., Vescovi, L., 2010. The CC-Bio project: studying the effects of climate change on Quebec biodiversity. Diversity 2, 1181–1204
- Hoekstra, J.M., Boucher, T.M., Ricketts, T.H., Roberts, C., 2005. Confronting a biome crisis: global disparities of habitat loss and protection. Ecol. Lett. 8, 23–29.
- Mittermeier, R.A., Myers, N., Robles-Gil, P., Mittermeier, C.G., 1999. Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. CEMEX/Agrupación Sierra Madre, Mexico City.

- Mittermeier, R.A., Robles-Gil, P., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J., Da Fonseca, G.A.B., 2004. Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. CEMEX, Mexico City.
- Mittermeier, R.A., Turner, W.R., Larsen, F.W., Brooks, T.M., Gascon, C., 2011. Global biodiversity conservation: the critical role of hotspots. In: Zachos, F.E., Habel, J.C. (Eds.), Biodiversity Hotspots. Springer Publishers, London, pp. 3–22.
- Myers, N., 1988. Threatened biotas: ‘‘hot spots’’ in tropical forests. Environmentalist 8, 187–208.
- Myers, N., 1990. The biodiversity challenge: expanded hot-spots analysis. Environmentalist 10, 243–256.
- Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858.
- Pereira, H.M., Ferrier, S., Walters, M., Geller, G.N., Jongman, R.H., Scholes, R.J., Bruford, M.W., Brummitt, N., Butchart, S.H., Cardoso, A.C., Coops, N.C., Dulloo, E., Faith, D.P., Freyhof, J., Gregory, R.D., Heip, C., Hoft, R., Hurtt, G., Jetz, W., Karp, D.S., McGeoch, M.A., Obura, D., Onoda, Y., Pettorelli, N., Reyers, B., Sayre, R., Scharlemann, J.P., Stuart, S.N., Turak, E., Walpole, M., Wegmann, M., 2013. Ecology. Essential biodiversity variables. Science 339, 277–278.
- Pimm, S.L., Jenkins, C.N., Abell, R., Brooks, T.M., Gittleman, J.L., Joppa, L.N., Raven, P.H., Roberts, C.M., Sexton, J.O., 2014. The biodiversity of species and their rates of extinction, distribution, and protection. Science 344, 1246752.
- Selig, E.R., Turner, W.R., Troeng, S., Wallace, B.P., Halpern, B.S., Kaschner, K., Lascelles, B.G., Carpenter, K.E., Mittermeier, R.A., 2014. Global priorities for marine biodiversity conservation. PLoS One 9, e82898.
- Venter, O., Fuller, R.A., Segan, D.B., Carwardine, J., Brooks, T., Butchart, S.H., Di Marco, M., Iwamura, T., Joseph, L., O'Grady, D., Possingham, H.P., Rondinini, C., Smith, R.J., Venter, M., Watson, J.E., 2014. Targeting global protected area expansion for imperiled biodiversity. PLoS Biol. 12, e1001891.
- Williams, K.J., Ford, A., Rosauer, D.F., De Silva, N., Mittermeier, R., Bruce, C., Larsen, F.W., Margules, C., 2011. Forests of east Australia: the 35th biodiversity hotspot. In: Zachos, F.E., Habel, J.C. (Eds.), Biodiversity Hotspots. Springer Publishers, London, pp. 295–310.
- Worm, B., Lotze, H.K., Myers, R.A., 2003. Predator diversity hotspots in the blue ocean. Proc. Natl. Acad. Sci. USA 100, 9884–9888.

9.10 SUGGESTED READINGS

- Bellwood, D.R., Hughes, T.P., Folke, C., Nystrom, M., 2004. Confronting the coral reef crisis. Nature 429, 827–833.
- Cañadas, E.M., Fenu, G., Peñas, J., Lorite, J., Mattana, E., Bacchetta, G., 2014. Hotspots within hotspots: endemic plant richness, environmental drivers, and implications for conservation. Biol. Conserv. 170, 282–291.

- Hughes, T.P., Bellwood, D.R., Connolly, S.R., 2002. Biodiversity hotspots, centres of endemicity, and the conservation of coral reefs. Ecol. Lett. 5, 775–784.
- Jepson, P., Canney, S., 2001. Biodiversity hotspots: hot for what? Glob. Ecol. Biogeogr. 10, 225–227.
- Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858.
- Possingham, H.P., Wilson, K.A., 2005. Biodiversity: turning up the heat on hotspots. Nature 436, 919–920.
- Smith, T.B., Kark, S., Schneider, C.J., Wayne, R.K., Moritz, C., 2001. Biodiversity hotspots and beyond: the need for preserving environmental transitions. Trends Ecol. Evol. 16, 431.

9.11 TERMINAL QUESTIONS

1. India is a mega biodiversity country. Discuss with suitable examples.
2. Explain as to how protection of biodiversity hot spots alone can reduced upto 30 % for the current rate of species Extinction.
3. Discuss the role of Government agencies for conserving the mega biodiversity of the country.
4. What are the various concepts for Hotspot identification? Discuss.
5. Your friend comments that hotspots are not that important because hotspots only focus on plants, not animals, and it’s most important to save the animals. Explain in a few sentences why you agree or disagree with your friend’s statement.
6. How many Hotspots we have globally or national?

UNIT-10 FLORISTIC DIVERSITY OF INDIA AND ENDEMISM

Contents

10.1 OBJECTIVES

After reading this unit students will be able-

- to know about the different floristic regions of the India
- acquaint with the floral profile of the different floristic regions
- acquaint with the concept of the Endemism

10.2 INTRODUCTION

India, with 2.4% of the world's area, has over 8% of the world's total biodiversity, making it one of the 12 megadiversity countries in the world. This status is based on the species richness and levels of endemism recorded in a wide range of taxa of both plants and animals. This diversity can be attributed to the vast variety of landforms and climates, resulting in habitats ranging from tropical to temperate and from alpine to desert. Adding to this is a very high diversity of human-influenced ecosystems, including agricultural and pasture lands, and a diversity of domesticated plants and animals, one of the World's largest. India is also considered one of the world's eight centres of origin of cultivated plants. Being a predominantly agricultural country, India also has a mix of wild and cultivated habitats, giving rise to very specialized biodiversity, which is specific to the confluence of two or more habitats.

10.3 FLORISTIC REGIONS OF INDIA

The tendency to classify ecological regions, and plant and animal groupings, according to their geographical distribution and their essential similarities and differences, is not new. Traditional human communities did this on the basis of their own understanding, though their knowledge was necessarily somewhat restricted in its geographical spread (Banwari 1992; Gurukkal 1989). Unfortunately, this aspect of traditional community knowledge is not well appreciated or studied. In modern times, biogeographical classification started in the latter half of the 19th century, with Elwes (1873) using the distribution of animals to classify bioregions, and Clarke (1898) followed by Hooker (1907), using plant distribution to the same end. What distinguished most of these early attempts and indeed all except some recent efforts was that they were either phytogeographic, i.e., based solely on plant distribution, or zoogeographic, i.e., based only on animal distribution. An attempt to synthesise the two approaches, or come up with a fresh classification based on the combination of plant and animal distribution, is very recent, and has been prompted by the need to use such zonation in fixing conservation priorities. These three kinds of approaches have been used or analysed by several authors recently, including Mani (1974), Puri *et al.,* (1983), Meher-Homji and Mishra (1973), and Rodgers and Panwar (1988).

Rodgers *et al*., (2002) recognizes ten biogeographic zones divided into twenty-six biotic provinces in India. Biogeographic zones of India and their spatial extent is presented in Table 1.

Table-1: Biogeographic zones of India and their spatial extent

S.No.	Zone	Biotic Province	Area	% of India's land area
1	Trans-Himalaya		174225	
		Ladakh	98618	3.3
		Tibetan Plateau	75607	2.3
2	Himalaya		210385	
		North-Western	69033	2.1
		Western	52596	1.6
		Central	6575	0.2
		Eastern	82182	2.5
3	Desert		213672	
		Kachchh	36160	1.1
		Thar	177512	5.4
4	Semi-Arid		545686	
		Central India	121629	3.7
		Gujarat-Rajputana	424057	12.9
5	Western Ghats		131491	
		Malabar Coast	65745	2
		Western Ghat Mountains	65745	2
6	Deccan Peninsula		1377363	
		Deccan South Plateau	341875	10.4
		Deccan Central Plateau	410908	12.5
		Eastern Plateau	207098	6.3
		Chhota Nagpur	177512	5.4
		Central Highlands	239970	7.3
7	Gangetic Plain		355024	
		Upper Gangetic	207098	6.3
		Lower Gangetic	147927	4.5
8	Coasts		82182	
		East Coast	62458	1.9
		West Coast	19724	0.6

9	North East		170938	
		Brahmaputra Valley	65745	2
		North-Eastern Hills	105192	3.2
10	Islands		12971	
		Andaman Islands	6575	0.2
		Nicobar Islands	3287	0.1
		Lakshadweep Island	3110	0.1
	Marine Influenced Area		10440	0.3
	Grand Total		3287263	

(Source: Wildlife Institute of India (Rodgers et al., 2002)/Zoological Survey of India)

Trans-Himalaya

The Trans-Himalaya zone covers mainly the districts of Ladakh and Kargil in Jammu and Kashmir, and the Spiti valley, Lingti plains (Lahaul valley), and Pooh tehsil (district Kinnaur) in Himachal Pradesh. Small areas in the rain shadows of Nanda Devi range (Uttaranchal) and Kangchendzonga range (Sikkim) are also part of this zone (Mehta and Julka 2002). The area is a distinct biogeographic unit with harsh climatic conditions and is usually referred to as cold desert (Rodgers and Panwar 1998). The region is the most elevated zone on the earth and varies from 2800 m in the Indus to over 7000 m in the Himalayan and Karakoram ranges (Mehta and Julka 2001). The vegetation is primarily of dry alpine scrub formation, chiefly of *Juniperus* spp. The other genera that contribute to the sparse vegetation are *Saxifrga*, *Draba*, *Ephedra*, and *Carex*.

Himalaya

The Himalaya zone consists of an area of 210385 sq km, approximately 6.4% of the country's total land surface. It includes northwest Himalaya (Kashmir to the Sutlej river in Himachal Pradesh), west Himalaya (Sutlej river to the Gandak river in Nepal), central Himalaya (Gandak river in Nepal through West Bengal and Sikkim to central Bhutan) and east Himalaya (central Bhutan and Arunachal Pradesh). Himalaya supports a remarkable assemblage of vegetational formation. Broadly subtropical, temperate, subalpine, and alpine forest types are met with in this region. Chir-pine, tall conifers, Oaks are common in the West Himalaya and show a distinct altitudinal distribution while the slopes of East Himalaya are occupied by colorful *Rhododendrons*, bamboos, primulas and orchids.

Desert

The Indian desert is the northwestern boundary of India and covers mainly the western and northwestern regions of Rajasthan and part of Kachchh region of Gujarat in the southwest. It has an elevation of about 350-450 m above sea level at the Aravalli range in the east, about 100 m in the south and west and about 20 m in the Rann of Kachchh (Baqri and Kankane 2001). Indian dessert is characterized by *Leptadenia*, *Crotalaria*, *Citrulus* species. Tree species are sparce and mainly represented by *Acacia*, *Tecomella* and some multipurpose tree species like *Prosopis*, Bushes of *Ziziphus* and *Capparis* species.

Semi-Arid

This region is a zone of transition between the true desert in the west to the extensive communities of the Deccan Peninsular India, to the south and east. This zone includes the Punjab plains, Delhi, Haryana, fringes of Jammu and Kashmir, Himachal Pradesh, Western edges of Uttar Pradesh, eastern Rajasthan, eastern Gujarat and northwest Madhya Pradesh. The Semi-arid zone represents a characteristic savannah woodland and dry deciduous and tropical thorn forest zone in Western India. The Aravalli System constitutes the heart of this zone, which primarily supports two types of vegetation: Tropical Dry Deciduous Forest and Tropical Thorn Forest. The semi-arid vegetation chiefly constists of thorn-scrub forests of *Ailanthus excelsa*, *Capparis decidua*, *Prosopis cineraria*, *Acacia* sp. and *Boswellia serrata*.

Western Ghats

The Western Ghats stretch from the Tapti river in the north to Kanyakumari in the south, along the west coast of peninsular India through the states of Gujarat, Maharashtra, Goa, Karnataka, Tamil Nadu and Kerala (Lakshminarayana *et. al.*, 2001).The Western Ghats zone is one of the 25 biodiversity 'hotspots' in the world (Myers *et. al.*, 2000) and is one of the major tropical evergreen forested regions in India, exhibiting enormous plant diversity. About 4000 species of flowering plants occur in the region, which harbours nearly 27% of the total flora in India (Nayar 1996). Among these, 1500 species are endemic (Mackinnon and Mackinnon (1986). The Western Ghats region is a major genetic estate with a rich biodiversity of ancient lineage. Western Ghats comes next to Himalayan zone in terms of floristic richness and diversity. More than 4000 species of flowering plants are expected here, out of which 1500 species are endemic. Diversity of forest types constitute this zone. The moist deciduous forests contain highly valued timber species such as *Dalgergia latifolia, Terminalia crenulata*, *Pterocarpus marsupium* and *Tectona grandis*. The wet evergreen forests include species of *Mesua*, *Calophyllum*, *Hopea* and *Dipterocarpus*. At higher level montane flora generally known as Shola formation is common. Species of *Syzygium, Machilus, Elaeocarpus, Wendlandia* are common.

Deccan Peninsula

The Deccan Peninsula biogeographic zone includes a major portion of the states of Maharashtra, Madhya Pradesh, Uttar Pradesh, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa and Bihar. The zone is relatively homogenous and ranges from semi-arid to moist deciduous/ semi-evergreen type of climate. The central highlands comprise the Vindhya and Satpura hill ranges, Chhota Nagpur Plateau, Eastern Ghats, Tamil Nadu Plains and Karnataka Plateau (Cherian 2001). The Vindhya and Satpura hill ranges are known for a rich diversity of flora. A major portion of the Deccan Peninsula is covered by Tropical thorn forests and Tropical dry and moist deciduous forests. *Tectona grandis*, *Anogeissus latifolia*, *Boswellia serrata*, *Butea monosperma* and several other thorny species of semi-arid zone are common here. *Hardwickia binata*, an endemic Caesalpiniaceae tree species occurs scattered in patches on the drier parts of the Peninsula. The tropical moist deciduous forest chiefly includes *Adina cordifolia*, *Chloroxylon swietenia*, *Diospyros exsulpta* and in some parts of southeastern Madhya Pradesh *Shorea robusta* occurs.

Gangetic Plains

This zone includes the Gangetic divide, the Upper Gangetic plain, the Middle Gangetic plain and the Lower Gangetic plain (Hooker 1907). This zone is mostly under agriculture and supports dense human population stretching from eastern Rajasthan through Uttar Pradesh to Bihar and West Bengal. The Gangetic plain includes the area adjacent to Terai-Bhabar tracts in Uttar Pradesh, Bihar and West Bengal. In this particular zone natural vegetation has been replaced by cultivated plants. In the Terai areas (foothills) the natural stands of tall grasses of *Themeda*, *Saccharum* and *Phargmites* admist which a few scattered trees exists.

Coasts

The coastline of India stretches from Gujarat to Cape Comorin (Kanyakumari) in the west, and onwards from Cape Comorin to the Sundarbans in the east. The long stretch of coastline in the mainland has a very diverse set of biotic communities. This zone includes two major vegetation types mangrove forests and beach forests. The most characteristic tree species of beach forest are *Casuarina equisetifolia*, *Anacardium occidentale* (planted), *Manilkara* species, *Calophyllum inophyllum* and *Hernandia peltata*.

North-East Region

The north-east Indian biogeographic zone is most significant as it represents the transition zone between the Indian, Indo-Malay and Indo-Chinese biogeographic regions, as well as a meeting-place of Himalayan Mountains with those of Peninsular India. It comprises eight states i.e., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The region acts as a biogeographic gateway for plant migration. In India, apart from the Western Ghats. Northeast India is one of the 25 biodiversity 'hotspots' in the world (Myers *et. al.*, 2000). About 50% of the total number of species of India occur in this zone which also includes a portion of Arunchal Pradesh. The presence of a large number of primitive flowering plants (Table 2) has prompted Takhtajan (1969) to call it the “Cradle of Flowering Plants”. Many primitive angiosperms occur in the humid tropics of northeast India and east Himalaya. The vegetation of northeast India is rich and diverse and is broadly classified into tropical, subtropical, temperate types. *Shorea assamica*, *Diplterocarpus macrocarpa* are the important tree species of the tropical zone. *Pinus kesiya* is the principal conifer in the subtropical zone. Species of *Quercus*, *Castanopsis*, *Rosa*, *Photinia*, *Prunus* and *Sorbus* are conspicuous in the temperate vegetation.

Table-2: Primitive Angiosperm genera in India

Families	**Genera**
Magnoliaceae	*Magnolia*, *Manglictia*, *Michelia*, *Pachylarnax*, *Paramichelia*, *Talauma*
Tetracentraceae	*Tetracentron* (*T. sinense* var. *himlaayana*)
Illiciaceae	*Illicium*
Eupteliaceae	*Euptelea*
Annonaceae	*Alphonsca*, *Annona*, *Artabortys*, *Cyathocalyx*, *Desmos*, *Fissitigma*, *Melodorum*, *Goniothalamus*, *Melodorum*, *Miliusa*, *Mitrephora*, *Orophea*, *Polyalthia*, *Trivalvaria*, *Unona*, *Uvaria*
Myristicaceae	*Horsfieldia*, *Kuema*, *Myristica*
Schisandraceae	*Kadsura* (*K. heteroclite*)
Lauraceae	*Actinodaphne*, *Alseodaphne*, *Beilschmiedia*, *Cinnamomum*, *Cryptocarya*, *Dehaasia*, *Endiandra*, *Lindera*, *Litsea*, *Machilus*, *Neociannamomum*, *Presea*, *Phoebe*
Chloranthaceae	*Chloranthus* (*C. elatior*)

Islands

Islands are essentially in two major groups the Lakshadweep islands and the Andaman group of islands. The Lakshadweep Islands are an archipelago of 27 small islands stretching from 8° to 12° N latitude and 71° to 74° E longitude in the Arabian Sea. They are 320 kms away from the Kerala coast. The Andaman and Nicobar Islands are an elongated north-south oriented group of 348 islands in the Bay of Bengal stretching for 590 km from 6° to 13° N latitude and 92° to 93° E longitude. The Andaman Islands are about 190 km from Cape Negrais in Burma, the nearest point on the mainland. Five islands close together constitute the Great Andaman (300 km long), and the Little Andaman lies to the south. The Nicobar groups of Islands are separated from the Andamans as well as internally from each other by 800 m deep channels. The vegetation of the island can be broadly classified as littoral and inland types. The littoral forests are composed of trees like *Manilkara littoralis*, *Calophyllum inophyllum*, *Terminalia catappa*, *Barringtonia asiastica* and mangroves like *Rhizophora mucronata*, *R. apiculata*, *Avicennia marina*, *Lumnitzera littorea*, *Nypa fruticans* and few others. The inland vegetation includes the evergreen and deciduous forests with a number of economically important timber species such as *Dipterocarpus grandis*, *Pterocarpus dalbergioides*, *Terminalia bialata*, *Albizia lebbeck*, *Ailanthus kurzii*.

10.4 FLORA AND VEGETATION

As indicated above, the different parts of the country are covered by the distinct vegetational types. The richness and diversity of flora of India can be appreciated by the fact that as many as 10 biogeographic regions representing three basic biomes and two natural realms as identified by Udvardy (1975) are recognized within the territory of the Indian Republic. These are Himalayan highlands, Thar dessert, Malabar rain forest, Indo-Ganges monsoon forest, Deccan thorn forest, Coromandel, Mahanadian, Bengalian rain forest, Laccadive islands, Andaman and Nicobar islands.

It is estimated that over 45,000 species of plants are accounted for India which represent 11% of the known species of the World. These are distributed in the following groups: Angiosperms: 15000 species; Gymnosperms: 64 species; Pteridophytes: 1022 species; Bryophytes: 2584 species; Lichens: 1600 species; Fungi: 23000 species; Algae: 2500 species and Bacteria: 850 species.

The flowering plants of India comprise about 15000 species and represent 6 % of the World's known flowering plants (Nayar, 1977). About 315 families and 2250 genera of flowering plants are known to occur in India in different ecosystems. The ten largest families in terms of numbers of species are listed in table 3. On the other end of the spectrum there are several monotypic families. Over 60 families are reported to be presented by only one species in India like Coriariaceae, Turneraceae, Illiciaceae, Ruppiaceae etc.

Table-3: Ten large families of flowering plants in Indian Flora

S.No.	**Name of the family**	**No. of genera (approximate)**	**No. of species (approximate)**
1	Poaceae	255	1225
2	Fabaceae	179	1152
3	Orchidaceae	145	990
4	Asteraceae	161	1000
5	Rubiaceae	90	495
6	Cyperaceae	24	449
7	Euphorbiaceae	74	419
8	Lamiaceae	68	393
9	Acanthaceae	84	379
10	Scrophularaceae	66	356

Nearly 17 % of the species of Indian flora are tree species and they predominantly occur in Euphorbiaceae, Lauraceae, Annonaceae, Rubiaceae, Moraceae, Fabaceae, Rutaceae, Arecaceae, Meliaceae, Mimosaceae and Caesalpiniaceae.

The Indian Sub-continent has approximately half of world's aquatic flowering plants (Lavania *et al.*, 1990). The aquatic families in the Indian flora are Alsimataceae, Aponogetonaceae, Azollaceae, Barclayaceae, Butomaceae, Cabombaceae, Hydrocharitaceae, Lemnaceae, Isoetaceae, Nymphaeaceae, Podostemaceae, Pontederiaceae, Potamogetonaceae, Ruppiaceae, Salviniaceae, Trapaceae, Typhaceae etc.

The families having characterisitc insectivorous plants are Droseraceae (3 species), Nepenthaceae (01 species) and Lentibulariaceae (36 species). The parasitic families are represented by Loranthaceae (46 species), Santalaceae (10 species), Balanophoraceae (06 species) and Cuscutaceae (12 species). There are several unique root parasites in the country.

Sapria himalayana of the family Rafflesiaceae is a recently discovered large root parasite of great botanical interest.

The size, shape, biology and economic aspects of different taxa again provide a highly varied spectrum. Several reputed medicinal plants constitute the natural component of Indian flora. These are *Dioscorea deltoidea*, *Atropa acuminata*, *Aconitum heterophyllum*, *A. ferox*, *Ephedra gerardiana*, *Nardostachys grandiflora*, *Rauvolfia serpentiana*, *Sassurea lappa*, *Coptis teeta*, *Gentiana kurroo*, *Mesua ferrea*, *Swertia chirayita*, *Podophyllum hexandrum*, *Artemesia* species, *Phyllanthus emblica*, *Withania somnifera*, *Andrographis paniculata*, *Berberis* species, *Mentha* species etc.

Certain groups like orchids, rhododendrons, bamboos, legumes, balsams and primulas exhibit a remarkable diversity in the Indian region. The diversity in a few important groups is discussed below:

Diversity in Orchids

The orchids which are well-known for their showy and long-lasting flowers are represented by diverse epiphytic and terrestrial forms. There are about 163 terrestrial genera and 1100 species, of which about 780 species occur in northeast India and Eastern Himalaya. Some of the large genera having maximum diversity are *Habenaria* (95 species), *Dendrobium* (75 species), *Bulbophyllum* (50 species), *Liparis* (46 species) and *Coelogyne* (35 species).

Diversity in Bamboos

Bamboos play an important role in the economy of the country and are associated with the human kind since ancient times. Tropical Asia including the India is the main centre of bamboo diversity. Bamboo forests come up in both tropical and temperate regions. Approximately 13% of the total forest area in India is covered by Bamboos. Out of 18 genera and 130 species so far known in India, 15 genera and 63 species are represented in northeastern India, which is also considered as the centre of genetic diversity for the species of *Bambusa*, *Dendrocalamus*, *Arundinaria* and a few others. Some of the dominant genera area *Arundinaria* (10 species), *Bambusa* (22 species) and *Dendrocalamus* (15 species).

Diversity in the Genus *Rhododendron*

The genus *Rohdodendron* of the family Ericaceae is another remarkable group bearing showy flowers, which have maximum diversity in the Himalaya. Out of the total 90 species in India nearly 80 species are confined to east Himalaya whereas only one species *Rhododendron arboreum* extends its distribution to Nilgiris in south India. *R. nivale* is the smallest Rhododendron in India. In Sikkim, we have the *Rhododendron* sanctuary only for the conservation of *Rhododendron* genus.

Diversity in Legumes

The economic importance of legumes is too well recognized. Leguminosae is the second largest family in the Indian region. Out of 179 genera and 1152 species in India (Sanjappa, 1991), 236 taxa (23%) are endemic. Approximately 56 % of the total Leguminosae of India is represented in the Himalayan region (Rao and Husain, 1993). Some of the dominant genera of legumes are *Crotalaria* (96 species), *Astragalus* (72 species), *Acacia* (70 species), *Indigofera* (60 species), and *Dalbergia* (35 species).

10.5 ENDEMISM

The idea of endemism dates back to more than 200 years, and has been employed, as it is actually understood, by de Candolle. Since then, the concepts of endemicity and areas of endemism have been widely discussed. Some problems around these concepts emerge from the diverse uses and interpretations given to them in literature (Harold and Moii). Although differences between diverse uses as regards connotations could seem minor, the lack of precision in the definition of these concepts hinders an unambiguous interpretation and causes confusion. Additionally, numerous expressions, such as “generalized track”, “track”, “biotic element”, “centers of endemicity”, “units of co-ocurrence”, among others, are commonly used as synonyms of area of endemism. Although basically related with the term “areas of endemism”, these concepts refer to different patterns of distribution and are defined on different theoretical grounds.

Brief Review of ideas on Endemism

Naturalists and Botanists have recognized the existence of rare or endemic plants for centuries. Cain (1944) ascribes the origin of the world endemic as it is applied to the distribution of organism to A. De Candolle (1855) the great voyages of discovery from the seventeen through nineteenth centuries brought to light countless rare and endemic taxa. Linnaeus’s *Species Plantarum* of 1753 lists no rarities from different areas but only recorded some local endemic species, some of them are still rare and some are extinct. Adolph Engler (1882) appears to be the originator of the dichotomy of old Vs new endemics, which has been extensively by other plant geographers ever since Stebbins (1942) and Stabbins and Major (1965). Willis (1922) quantified the idea of the youthful endemic with his J-shaped or hollow curves; they became the backbone of his controversial and largely discredited theory of age and area. Stebbins (1942) provided a genetical explanation for the epibiotic or relictual endemic. Stebbins and Major (1965) recast Cain’s two categories as paleoendemism and neoendemism. These authors point to persistent defects in the new vs old endemic dichotomy. Stabbins and Major based their classification upon the way in which narrow endemics have achieved their restricted distribution, since this varies among species; this system was also proposed by Favarger and Contandriopouplos (1961). Stebbins and Major’s system incorporates the age of endemic, its systematic position, and cytological data. In groups of related species, diploids are older than derivative low polyploids, while both high polyploids and diploids are paleoendemics. Endemics with more than one disjunct population are most likely (paleoendemics), while endemics confined to a single population can be either paleoendemics or neoendemics. Stebbins and Major use the ploidal level and its modes of origin both to categories endemics and to explain their origin. Paleoendemics are ancient vestiges of taxa that were once more widespread. Their present relictual status is preseumably the result of the increasing constriction of their specialized habitats over time. The neoendemics, on the other hand, are recent in origin, have just split off from a parental entity, and may be poised for a further expansion of their ranges and gene pools. *Plantago cordata* (Meagher et al., 1978) and *Stephanomeria malheurensis* (Gottlieb, 1979) demonstrate that both paleoendemics and neoendemics indeed occur, but we currently have no way to evaluate their relative proportion in floras. Between the two extremes in age of endemics, there are, of course, endemics of intermediate age; they remain narrow endemics, confined to a restricted, local habitat. Recent reviews agree that there are multiple causes of rarity and endemism. Neither genetics, ecology, nor history alone will suffice to explain the origin of endemic taxa. Moreover, the interplay among various casual factors will vary in intensity, depending on the particular taxon under scrutiny. Stebbins (1942) proposes the gene pool/niche interaction theory to explain origin or rarity and endemism. His notion is grounded on the assumption of multiple causation:

“According to this theory, the primary cause of localized of endemic distribution patterns is adaptation to a combination of ecological factors that are themselves localized. Factors of soil texture or chemical composition are the most common but by no means the only ones. Next to climate and edaphic factors, those inherent in the gene pool of the population are of critical importance. They include the total amount of variability, the amount of variability that can be released at any one time, and the amount of variation that can be generated with respect to those particular characteristics that affect most strongly the establishment of new populations (Stebbins, 1980).

The Geography of Endemism

The narrow or local endemic is the one that best fits the colloquial notion of rarity. However, the term endemism, in its classical biogeographic usage, does not necessarily imply rarity or even small range. Thus, continental or regional endemics need not be, and in fat seldom are, rare. For example *Quercus chrysolepis* and *Pinus sylvestris* are endemic to their respective continents or extensive regions, but they are hardly rare. Good (1974) states that endemism, in the sense of restriction to a floristic province, accounts for more than 90% of the worlds plant species. Further, endemism manifests itself at various taxonomic levels from variety to higher category. Many of the smaller angiosperm families are endemic (Good 1974) and are found in the tropics and Australasia.

Three primary factors –geographic are, ecological breadth and isolation. Carlquist (1974) describe the distribution of endemics. Endemism is found on all land massess of the world, both continent and islands and in all major biomes. More curious is the well-known fact, first identified by Charles Darwin that the quantity and quality of endemism differ among the major geographic, topographic and vegetation types. For examples, while species number is smaller for island than for areas of comparable size on continents, the islands have higher proportions of endemics. Most oceainc islands are far richer in endemics than isalnd, their endemics would perforce to be narrowly distributed i.e., true rarities.

Endemic plants also are distributed unevenly across the land areas of the world. Some places, like mountains and islands, are rich in endemics, while boreal and arctic regions are relatively poor in them. Many parts of the world are well-known centres of endemics: California, The European Alps, The Mediterrnean region, Alpine regions of Central Africa, New Caledonia, Hawaii, the Cape region of South Africa, and the Sino-Himalayan region. Nonetheless, examples of narrow endemics abound in nearly all floras.

Generally Endemism is a unique phenomenon in the geographical distribution of species. Endemic species are restricted to extremely small ranges, even a single rock out crop. The environmental factors and topography play an important role in speciation. Especially in the Himalayan context, high mountain peaks and deep river valley, together with the environmental factors, play important role in the range restriction/speciation.

10.6 SUMMARY

Module provides the basic information regarding floristic region of the India, Biogeographic zones of India and their extent. Each category wise clarifications and parts covered in each category was also discussed and also highlighted the important vegetations in each category. In this module an attempt was also made to highlight the primitive angiosperm genera of the India. Further diversity of various important groups like legumes, bamboos, orchids, and Important Himalayan genus *Rhododendron* was also discussed in details to let the students know that how much diversity exists in nature. Further attempt was also made highlight the concept of endemism right from the A. De Candolle, to present scenario and also review of concept of Endemism and the geography of endemism.

10.7 GLOSSARY

Angiosperm: *Angiosperms* are seed-bearing vascular plants. Their reproductive structures are flowers in which the ovules are enclosed in an ovary.

Geography: Geography is a field of science devoted to the study of the lands, the features, the inhabitants, and the phenomena of Earth.

Endemism: a species which is only found in a given region or location and nowhere else in the world.

Alpine Species: Plants grows at higher altitude where generally no tree species are available.

Evergreen: An evergreen is a plant that has leaves throughout the year, always green.

Deciduous: Shedding or losing foliage at the end of the growing season:

Biodiversity: generally refers to the variety and variability of life on Earth.

10.8 SELF ASSESSMENT QUESTIONS

10.8.1 Multiple Choice Questions

1-Which of the following terms is used for virgin vegetation which is purely Indian in origin?

(i) Endangered species (ii) Endemic species

(iii) Exotic species (iv) Normal species

2- Which of the following types of natural vegetation have originally come to India from abroad?

(i) Rare species (ii) Endemic Species
(iii) Endangered species (iv) Exotic Species

3- How many Biogeographic regions are present in India

(i) 12 (ii) 10
(iii) 15 (iv) 16

4- Ladakh is mainly located in ………………..zone

(i) Island (ii) Gangetic Plain
(iii) Trans Himalaya (iv) Coasts

5- Himalayan Rhododendron belongs to the family………………

(i) Ericaceae (ii) Bamboo
(iii) Orchids (iv) Legumes

10.8.1 Answer Keys: 1-(ii); 2-(iv); 3-(ii); 4-(iii); 5-(i)

10.9 REFERENCES

- Banwari, P. 1992. Indian approach to Environment, New Delhi. Shri Vinayaka Publication.
- Baqri, Q. H. and Kankane, P. L. (2001). Deserts: Thar In: Ecosystems of India. ENVIS – Zool. Surv. India, Kolkata. Pp. 93-122.
- Cain, S.A. 1944. Foundation of Plant Geography. New York.
- Carlquist, S. 1974. Island Biology. New York. Columbia University Press.
- Casagranda M D, Taher L, Szumik C. Endemicity analysis, parsimony and biotic elements: a formal comparison using hypothetical distributions Cladistics 2012; 1 1-10.
- Cherian, P. T. (2000) Deccan Peninsula. In.: Alfred, J. R. B., A. K. Das, and A. K. Sanyal (2002) Ecosystems of India, ENVIS – Zool. Surv. India, Kolkata: 1-410.
- de Candolle A. 1855. Geography Botanique raisonnee. Vol 1,2, Paris, Mason. DOI: 10.1111/j.1096-0031.2012.00410.x. 20.
- Elwes, H.J. (1873): On the geographical distribution of Asiatic birds. Zool. Soc. Lond. 1873: 645-682.
- Engler A. 1882. Versucheiner Entwicklungsgeschichte der Pflanenwelt. Leip Zinp. Engelmann.
- Farager, C. and Contandriopouplos, J. 1961. Essaisurl’s endemism. Bull. Soc. Bot. Suisse. 71:384-408.
- Good R. 1974. The geography of folowering plants. London. Longman 4th edition.

- Gottlieb, L.D. 1979. The origin of phenotype in a recently evolved species. In Tropics in Plant population Biology, ed. O.T Solbring, S.Jain G.B. Johnson, P.H. Raven. PP. 264-86. New York: Columbia University Press.
- Gurukkal R (1989). Forms of production and forces of change in ancient Tamil society. Studies in History 5:159–175
- Hooker, I. D. 1907. lmper. Gaze of India. 1 : Oxford.
- Lakshminarayana, K.V., G.M. Yazdani & C. Radhakrishnan (2001). Western Ghats in Ecosystems of India. ENVIS-Zoological Survey of India, Kolkata, 349–369pp.
- Lavania, G.S., S.C. Paliwal and B. Gopal, 1990. Aquatic vegetation of the Indian subcontinent; p. 29-78. In E. Gopal (ed.). Ecology and management of the Aquatic Vegetation of the Indian Subcontinent. Dordrecht: Kluwer Academy Publishers
- Linder H P. On areas of endemism, with an example from the African Restionaceae.
- Linnaeus, C. 1753. Species Plantarum, Vol 140, 142, Stockholm: Salvii (Facsimile ed Reg Society)
- Lomolino M V. Ecology´s most general, yet protean pattern: the species-area relationship. Journal of Biogeography 2000; 27 17-26. DOI: 10.1046/j.1365-2699.2000.00377.x [21]
- MacKinnon, J. & K. MacKinnon. 1986. Review of Protected Areas System in the Indo-Malayan Realm. IUCN, Gland, Switzerland.
- Mani, M.S. (1974). Physical Features, pp. 11-59. In: M.S. Mani (ed). *Ecology and biogeography in India*. Dr. W. Junk B.V. Publishers, The Hague, 725pp.
- Meagher, T.R. Antonovics. J, Primack. P. 1978. Experimental ecological genetics in *Plantago.* III Genetic varation and demography in relation to survival of *Plantago cordata*, a rare species. Biological Conservation. 14:243-57.
- Meher- Homji, V.M & K. Mishra (1973). Phytogeographic of Indian subcontinent In; Progress of plant ecology in India. Mishra, R (ed). Yesterday and tomarrow publishing company, New Delhi.
- Mehta, H. S. and Julka, J. M. (2002) Mountains: North-west Himalaya. In: Alfred, J. R. B. (ed) Fauna Diversity of India. ENVIS Centre, Zoological Survey of India, Kolkatta.
- Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858
- Nayar, M.P. (1996). *"Hot Spots" of Endemic Plants of India, Nepal and Bhutan*. Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram.
- Nayar, M.P. 1977. Changing Patterns of the Indian Floras. **Bulletin Botanical Survey of India** 19: 145–155.
- Puri, G.S., V.M. Meher-Homji, R.K. Gupta & S. Puri. 1983. Phytogeographical ecology. pp. 115-210. In: Forest Ecology. 2nd edn. Oxford & IBH Publishing Company.
- R.R. Rao and Tariq Husain, 1993. Himalayan legumes: Diversity and Conservation. In: Himalayan Biodiversity Conservation strategies (ed. U. Dhar) Ch. 18, pp. 253 - 266.
- Rodgers, W. A. and Panwar, H. S. (1988) Planning a Wildlife Protected Area Net-work in India. 2 vols. Willdife Institute of India, Dehra Dun.

- Rodgers, W. A., Panwar, H. S. and Mathur, V. B. (2000). Wildlife Protected Area Network in India: A Review (Executive Summary). Wildlife Institute of India, Dehra Dun.
- Rodgers, W.A, H.S. Panwar & V.B. Mathur (2002). *Wildlife Protected Areas in India: A review (Executive Summary)*. Wildlife Institute of India, Dehradun, 44pp.
- Sanjappa, M. 1991. Legumes of India. Bishen Singh Mahendra Pal Singh, Dehradun.
- Stebbins, G.C. 1942. The genetic approach to problems of rare and endemic species. Madrono 6:241-58.
- Stebbins, G.C. and Major J. 1965. Endemism and speciation in the California flora. Ecol. Monogr. 35:1-35.
- Stebbins, G.L. 1980. Rarity of Plant Species: a synthetic view point. Rhodora 82 (829):77-86. Systematic Biology 2001; 50 892-912. DOI: 10.1080/106351501753462867. 16.
- Takhtajan, Armen. 1969 [English translation by C. Jeffrey]. Flowering Plants: Origin and Dispersal. Washington: Smithsonian Institution Press.
- Udvardy, M. D. F. 1975. A classification of the biogeographical provinces of the World. IUCN Occasional Paper No. 8. Morges, Switzerland.
- Willis, J.C. 1922. Age and AreaL A study in Geographical Distribution and origin of species London, Cambridge University Press.

10.10 SUGGESTED READINGS

- Dra Dolores Casagranda and Dra Mercedes Lizarralde de Grosso. 2013. Areas of Endemism: Methodological and Applied Biogeographic Contributions from South America. http://dx.doi.org/10.5772/55482.
- Arthur R. Kruckeberg, Deborah Rabinowitz. 1985.Biological Aspectes of Endemism in Higher Plants. Annual Review of Ecology and Systematics, 6:447-479.
- Darlington P J Jr. Biogeography of the southern end of the world. Distribution and history of the far southern life and land with assessment of continental drift. Harvard Univ. Press, Cambridge Mass.; 1965 236 pp.
- Morrone J J. On the identification of areas of endemism. Systematic Biology 1994; 43 438-441. DOI:10.1093/sysbio/43.3.438.

10.11 TERMINAL QUESTIONS

1. Define various biogeographic regions along with floral diversity.
2. In what way degree of endemism helps in classifying various biogeographic regions? Support your answer with suitable examples.
3. Discuss the role of Endemism in Indian floristic diversity.
4. Discuss the various biogeographic regions of the India.

5. In your own words, define what the term “endemic” means, in a few sentences. Give one example of an endemic species.
6. Define Endemism. Discuss its importance in context to the taxonomy.

LABORATORY COURSE

UNIT-1 STUDY THE ECONOMICALLY IMPORTANT PLANTS AND PLANT PRODUCT; THEIR COLLECTION, AND IDENTIFICATION –I

Contents

1.1 OBJECTIVES

After reading this unit student will be able-

- To describe the economical importance of various plants and plant products.
- To understand the identification, collection and maintenance of given plants

1.2 INTRODUCTION

The economic botany deals with application of botanical knowledge to the well being of mankind. Plants fulfill three major needs of human life viz., food, clothing and shelter. Most of the useful articles are also plant conversion products. The food primarily comes from plants in the forms of cereals, millets, pulses, vegetables and fruits. It becomes quite evident that knowledge of botany and its proper application led to the well-being of humanity in several ways. Some of the important plants and their uses are described in this chapter.

Practical Work

The plants of economic importance are kept in the laboratory as specimen, a student is expected to study their characters, identify the plant and the useful plant parts. The student should also be informed about different uses of the plant, cultivation, production and marketing statistics, etc. Therefore, comments written in practical record should include the following sequence.

1. Botanical name of the plant
2. Common English or Hindi name / vernacular name
3. Family
4. Part/parts of the plant used
5. Characters of the plant/ plant part
6. Cultivation, harvesting and processing
7. Uses of the plant part/ parts
8. World production/ Production in India

Practical record should also include diagrams of typical plant or plant part which is economically useful.

1.3 ECONOMICALLY IMPORTANT PLANTS AND PLANT PRODUCTS

1.3.1 Cereals

The cereals are the most important source of plant food for man. They constitute the most important group in the food plants of India. The cereals are the members of Gramineae family, and possess the characteristic fruit, the caryopsis. In this fruit the wall of the seed becomes fused with the ovary wall to form the husk. The term grain is applied to this type of fruit. There are six true cereals of which rice, wheat and maize, are most important cereals and they played a crucial part in the development of human civilization. Sometimes millets and sorghums are referred to as cereals. Cereals contain a high percentage of carbohydrates, together with a considerable amount of proteins and some fats, even vitamins are present.

A-WHEAT
Botanical name: *Triticum aestivum*
Hindi name: Gehoon or Gehu, Kanak
Family: Gramineae (Poaceae)
Part used: Edible part is caryopsis which is a fruit or grain.

Fig. 1.1 - *Triticum aestivum* (Wheat)

1. The grains are produced in an inflorescence which is a spike of spikelets. A mature grain consists of embryo, starchy endosperm, proteinaceous aleurone layer and husk.
2. Wheat flour is used for breads, cakes, biscuits and other confectionary products. Starch is employed in the preparation of beer, industrial alcohol and other a1coholic beverages, for sizing textiles, etc. Wheat straw is used for weaving chairs, mattresses, stuffing, baskets, packing, cattle feed, etc.
3. Largest producer of wheat is U. S. A., other wheat producing countries are Russia, China, Canada, Australia, India, etc.
4. In India it is a major cereal and covers 12% of the total area under cereals and 76% of that under winter cereals. It is mainly cultivated in U.P., Haryana, Punjab and M.P.
5. Various species used include *T. aestivum, T. durum, T. dicoccum, T. sphaerococum,* etc.

B-RICE
Botanical name: *Oryza sativa*
Hindi name: Chawal, Dhan
Family: Gramineae (Poaceae)
Part used: Edible part is caryopsis.

Fig. 1.2 - *Oryza sativa* (Rice)

1. Half the world's population, mostly the densely populated regions of the world, use this cereal as a staple food.
2. Plant is a large annual grass. The inflorescence is a panicle, its branches ending into a grain, covered by a husk.
3. The plant grows in hot, moist tropics. The area should be flooded with water during early stages.
4. The grains are used after removal of the husk and are very nutritious. Grain contains considerable amount of proteins, fat and starch. It also forms a raw material for alcoholic beverages. The stems are used as hat fibers and straw for mushroom cultivation.

5. China produces about 32% of the World's rice, India following with 21%. The highest yield in India comes from West Bengal and Bihar.

C-MAIZE (Corn)
Botanical name: *Zea mays*
Hindi name: Makka, Bhutta
Family: Gramineae (Poaceae)
Part used: Edible part is caryopsis.

Fig. 1.3 - *Zea mays* (Maize)

1. The plant is annual grass. It possesses both male and female flowers on the same plant. Grains are fruits (caryopsis) which contain proteins besides starchy endosperm.
2. Maize is used as a food for livestock; flour is used in the preparation of corn bread. Other uses include corn flakes, corn starch, syrup, corn oil, dextrin's, industrial alcohol. Fibers are also obtained from the main plant for making paper, yarn and as pith. Zein the maize protein is useful in the manufacture of artificial fibers.
3. U. S. A. produces half the world's output. Other corn producing countries include China, Argentina, Brazil, India, Mexico, etc.
4. In India, maize was introduced by East India company in 12th century. It is now chiefly cultivated in U. P., Bihar, Rajasthan, M. P., Punjab, A. P., etc.

D-PEARL MILLET
Botanical name: *Pennisetum glaucum*
Hindi name: Bajra
Family: Poaceae ⁄ Gramineae – (Grass family)
Part used: seed and leaves.

Fig. 1.4 - *Pennisetum glaucum* (Pearl

1. With ovoid grains of 3 – 4 mm length pearl millet has the largest kernels of all varieties of millet (not including sorghum) which can be nearly white, pale yellow, brown, grey, slate blue or purple. The height of the plant ranges from 0.5 – 4 m.
2. Pearl millet is one of the most extensively cultivated cereals in the world, after rice, wheat, and sorghum, and particularly in arid to semi-arid regions.
3. Pearl Millet is a principal food cereal cultivated in drought prone semi-arid regions of Africa and Indian subcontinent. In the U.S.A., Australia, Southern Africa, and South

America, pearl millet is grown most extensively as a forage crop. India is the largest producer of pearl millet. Rajasthan is the highest-producing state in India.

4. In addition to grain and forage uses, pearl millet crop residues and green plants also provide sources of animal feed, building material, and fuel for cooking, particularly in dry land areas.

5. Pearl millet is considered more efficient in utilization of soil moisture and has a higher level of heat tolerance than even sorghum and maize. The crop grows easily in that region due to its ability to withstand harsh weather conditions like drought and flood.

1.3.2. SUGAR AND STARCH

Sugars- The glucose manufactured by the green plant in photosynthesis, is almost universally present in plant cells, and the basic material of metabolism, glucose. The most important complex sugar is sucrose or cane sugar. The sugar is accumulated in abundant in sugarcane and sugar beets.

Starch- It occurs in all green plants, as complex carbohydrate. They are derived also from glucose and constitute the first visible product of photosynthesis. Commercial sources of starch are wheat, barley, Maize, Potatoes.

A-SUGARCANE

Botanical name: *Saccharum officinarum*

Hindi name: Ganna

Family: Gramineae (Poaceae)

Part used: Part of the plant used is stem for sugar extraction.

Fig. 1.5 - ***Saccharum officinarum***

1. This perennial grass grows 8 to 12 feet tall and is supported by stilt roots.

2. It grows best in warm humid weather.

3. The sugarcane is propagated by cutting of various sizes made from upper joints of old canes. These cutting are known as seed, are placed in trenches and nearly covered with soil.

4 The juice extracted from stem by expression is crystallized to manufacture sugar. The bagasse, molasses and filter mud which are by-products of sugar extraction are also used variously.

5. Chief cane sugar producing countries include Brazil, Cuba, India, China, Australia, etc.

6. Eighty percent sugar cane in is grown in north India with U .P. leading the list including Punjab, Bihar, Coimbatore and Haryana.

B-POTATO

Botanical name: *Solanum tuberosum*

Hindi name: Alu or Aaloo

Family: Solanaceae

Part used: Part of the plant used is underground stem tuber.

Fig. 1.6 - *Solanum tuberosum*

1. It is rich in starch and forms one of the most commonly used vegetable
2. Plant, a native of South America, is about foot tall, spreading annual. The underground branches swell at the tip to form tubers.
3. It grows over a wide range of soil and climatic conditions.
4. It is a universal staple food and is also used for sizing cotton and paper, production of dextrin's, alcohol, adhesives, etc.
5. About 90% production comes from Europe. In India it is largely cultivated in U.P., H.P., Punjab, M.P., etc.

1.3.3. PULSES OR LEGUMES

The legumes or pulses belong to the family Leguminosae. The Legumes are next in importance to cereals as source of human food. They contain more proteins than any other vegetable product. Carbohydrates and fats are also present in legumes. The protein occurs as aleurone grains in the same cells with the starch grain. The high content of protein is related with the presence nodules on the roots of legumes, containing nitrogen fixing bacteria. The pulses are also important from the point of view of animals nutrition, to which they contributes by their seeds, hulls and the green parts. The legumes have been cultivated and used as a food for centuries all over the world. About one-seventh of cultivated area in India is under pulses.

A-CAJAN PEA (Pigeon Pea)

Botanical name: *Cajanus cajan*

Hindi name: Arhar

Family: Papilionaceae (Leguminosae)

Part used: Edible part is the seed produced in pod or legume (fruit).

Fig. 1.7 - *Cajanus cajan* (Cajan Pea)

1. This annual plant is 6-7 feet tall. The leaves are trifoliate and flowers are borne in an axillary raceme.
2. It is grown as a mixed crop with jowar, bajra, ragi, cotton, maize, ground nut, etc.
3. Cajan pea is extensively used as *dal;* the green

leaves and tops as animal feed and also as a green manure.

4. It is chiefly grown in U.P., Rajasthan, Orissa, Maharashtra, Bihar, M.P., etc. India also export small quantities to U. K., France, Sri Lanka, Burma, etc.

B-SOYABEAN

Botanical name: *Glycine max*

Hindi name: Bhatwar or bhat, Soyabean

Family: Papilionaceae (Leguminosae)

Part used: Edible part is the seed produced in pod or legume.

Fig. 1.8-*Glycine max* (Soyabean)

1. It is a small, bushy, erect or prostrate annual that grows from 1-6 feet. Each pod contains 3-4 seeds.
2. It is grown alone or mixed with maize or sorghum; in fertile loam or sandy loam soils.
3. Soybean contains 32-42% proteins and has the highest lysine content (3.8%).
4. Besides being used variously as a food article, soybean flour, oil and milk are also extensively used.
5. Manchuria leads the production followed by Korea, Japan, China and Indonesia. India also grows a small amount of this crop.

C-BLACK GRAM

Botanical name: *Vigna mungo (Phaseolus mungo)*

Hindi name: Urd

Family: Papilionaceae (Leguminosae)

Part used: Edible part is the seed produced in pod or legume.

Fig. 1.9-*Vigna mungo* (Black Gram)

1. It is a herbaceous annual with procumbent branches, wooly in appearance. The leaves are trifoliate and the flowers are borne in clusters of five to six.
2. It is grown as a mixed crop in loamy or heavy soils in worm climate with good amount of rain.
3. It is highly prized for its high phosphoric contents. It is preferred in the preparation of *papars, kachoris,* etc. The seeds are eaten raw, germinated, salted or boiled. They are also used as *dal.* Straw is fed to the cattle.
4. The major areas of production in India include M.P., U.P., Punjab, Maharashtra, West Bengal, A.P. and Karnataka.

D-GREEN GRAM

Botanical name: *Vigna radiata* (*Phaseolus radiatus)*

Hindi name: Moong

Family: Papilionaceae (Leguminosae)

Part used: Edible part is a seed produced in pod or legume.

1. This small herbaceous annual grows to a height of 1-3 feet. The leaves are trifoliate and the yellow flowers are produced in clusters.
2. It grows on loams as well as on red and black soils as a kharif crop. It requires rainfall between 25-35 inches distributed throughout the year.
3. The green pods are used as vegetable, seeds as a pulse and straw and husk as fodder for cattle. Seeds are eaten as whole, as *dal*, parched, salted, germinated or boiled.
4. It is widely cultivated in India. The major states are M.P., U.P., Punjab, Maharashtra, Rajasthan, Karnataka, Tamil Nadu, Bihar and A.P.


Fig. 1.10 - *Vigna radiata* (Green Gram)

E-GRAM PEAS (Chick Peas or Bengal Gram)

Botanical name: *Cicer arietinum*

Hindi name: Chana

Family: Papilionaceae (Leguminosae)

Part used: Edible part is a seed produced in pod or legume.

1. The plant is branched, about 2 feet tall, leaves are pinnately compound and the fruit contains 1-3 seeds.
2. It is a dry crop grown in rabi season. It is best suited to areas of moderate rainfall with mild cold weather in water retentive clay loams and black cotton soils.
3. Gram is eaten raw, boiled or cooked. Green foliage is also used as a vegetable. It is used as a *dal* and gram flour or *besan* is used in various preparations.
4. It is rich in proteins, carbohydrates and contains varied amounts of vitamin A, B, and C. It also contains useful quantities of minerals.
5. In India it is mainly cultivated in U.P., Punjab, Rajasthan, M.P., Bihar, Maharashtra, A.P., West Bengal, Tamil Nadu and Karnataka.


Fig. 1.11 - *Cicer arietinum* (Gram Pea)

1.3.4. VEGETABLES

The term vegetable is usually applied to edible plants which store up reserve food in roots, stem, leaves and fruits, which are eaten raw, cooked and as salad. The vegetables rank next to cereals as sources of carbohydrate food. The nutritive value of vegetables is incredible, due to the presence of indispensable mineral salts and vitamins. India grows a large variety of vegetables belonging to the tropical, sub-tropical and temperate zones.

UNDERGROUND VEGETABLES

In these vegetables the food is stored in underground parts. The storage organs may be true roots or modified stems, such as rootstock, tubers, corms and bulbs.

(i) ROOT VEGETABLES

Fig. 1.12-*Ipomoea batatas* (Sweet Potato)

A-SWEET POTATO (Camote)
Botanical name: *Ipomoea batatas*
Hindi name: Shakarkand
Family: Convolvulaceae
Part used: Edible part is root (tuber) whereas leaf is used as folk medicine.

1. Tuberous-rooted perennial, usually grown as an annual; top herbaceous, drying back to ground each year. Stems forming a running vine up to 4 m long, usually prostrate and slender, with milky juice, lateral stem-branches arising from the short stem and usually not branched. Leaves ovate, borne on long petioles, palmately veined, angular or lobed, depending on variety, green or purplish. Flowers rare, seeds 1–4 per pod, flattened, hard-coated, angular.
2. The sweet potato is a native of tropical America. Now it is widespread in all tropics and some parts of the temperate zone, and found abundantly in South Seas, China, Japan, Indonesia, and India. It is cultivated throughout India.
3. Cultivated mainly for the tuber, used as vegetable, eaten raw, boiled and roasted, baked fried, or dried and ground into flour to make biscuits, bread, and other pastries.
4. Tubers also dehydrated in chips, canned, cooked and frozen, creamed and used as pie fillings. Leafy tops eaten as vegetable and sold in markets in Malaysia.
5. Folk Medicine- The leaf decoction is used in folk remedies for tumors of the mouth and throat. Sweet potato is a folk remedy for asthma, bug bites, burns, catarrh, ciguatera, convalescence, diarrhea, fever, nausea, stomach distress, and tumors.

B-BEETROOT (Garden beets, Sugar beets)
Botanical name: *Beta vulgaris*
Hindi name: Chukandar
Family: Amaranthaceae (Formally Chenopodiaceae)
Part used: Edible part is root and leaves whereas seed are used in folk medicine.

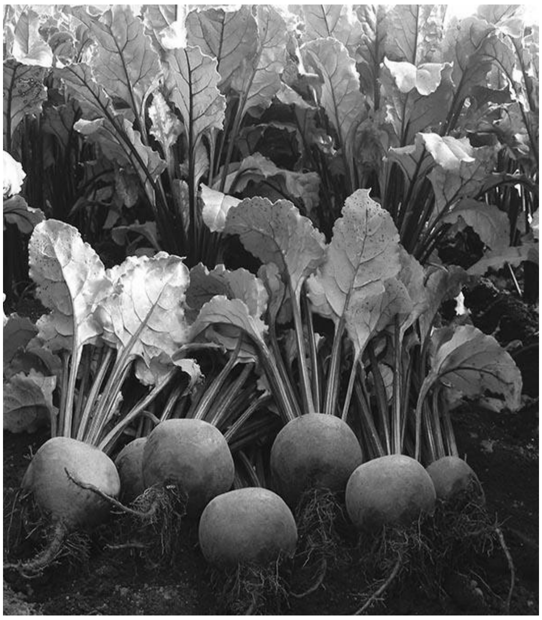


Fig. 1.13-*Beta vulgaris* (Beetroot)

1. Annual or biennial herb, leaves glabrous, ovate to cordate, dark green or reddish, frequently forming a rosette from the underground stem, roots conspicuously swollen at junction with stem; flowering stalk 1.2–1.8 m tall, flowers small, numerous in a tall open panicle, fruit an aggregate of 2 or more fruits forming an irregular dry body; in garden beets, roots are usually a deep red color and may be globular or cylindrical. Beet crops are propagated from seed, sown in early spring when the ground is suitable for tilling.
2. Generally used in vegetables salad. Garden beets are grown for the roots which are eaten cooked, as a vegetable, in salads or pickled, used as a important cattle food.
3. Refreshing juice is extracted from it. Sugar is manufactured from juice in European countries; it is the second most important source of sugar. Chard and spinach beet are grown for the leaves which are used as a potherb.
4. Many studies indicate that eating more plant foods, like beetroot, decrease the risk of obesity, overall mortality, diabetes, and heart disease and promote a healthy complexion and hair, increased energy, and overall lower weight.
5. Folk Medicine- The decoction prepared from the seed is a folk remedy for tumors of the intestines. Seed, boiled in water, is said to cure genital tumors. The juice or other parts of the plant is said to help tumors, leukemia and other forms of cancer.

C-RADISH
Botanical name: *Raphanus sativus*
Hindi name: Muli
Family: Cruciferae (Brassicaceae)
Part used: Edible part is root and leaves. Also root and seed are used in medicine.


Fig.1.14-*Raphanus sativus* (Radish)

1. They are annual or biennial plants with a fleshy tap root. They are grown all over the World, many varieties are cultivated differing in the shape and color of the roots. In India, they are chiefly cultivated in Uttar Pradesh, Punjab, Maharashtra and Baroda.

2. The roots, young leaves and the fruits are used as vegetable. Usually they are eaten raw, but may be cooked like other vegetables.
3. The roots are used as diuretic in urinary troubles, piles and gastrodynia. Juices of fresh leaves are diuretic and laxative.
4. The seeds are expectorant, diuretic and carminative. Seeds yield a non drying fatty oil suitable for soap making; also for edible purposes and as an illuminant. Hydrogenated oil is used in Japan in manufacture of crayon. Seed cake is rich in protein and appears to be suitable for use as manure and after removal of isothiocyanates use as a feed stuff.

D-CARROT

Botanical name: *Daucus carota*
Hindi name: Gajar
Family: Apiaceae
Part used: Edible part is root whereas seed are used in folk medicine.


Fig.1.15-*Daucus carota* (Carrot)

1. An annual or biennial herb, that grows between 30 and 60 cm tall, and is roughly hairy, with a stiff, solid stem. The leaves are tri-pinnate, finely divided and lacy. The fruits are oval and flattened, with short styles.
2. It is native to temperate regions of Europe and southwest Asia, and naturalized to North America and Australia. In India they may be chiefly grown in the Punjab, Uttar Pradesh and Madhya Pradesh.
3. Cultivated for the enlarged fleshy taproot, eaten as a raw vegetable, as salad or cooked in many dishes.
4. They are sold in bunches, or canned, frozen, or dehydrated. They may be baked, sautéed, pickled, and glazed, or served in combination with meats, in stews, roasts, soups, meat loaf or curries.
5. Carrot juice is beneficial for health. Essential oil is used to flavor liqueurs and perfumes.
6. Folk Medicine: Seeds are aromatic, carminative, diuretic, and stimulant, and are used for dropsy, chronic dysentery, kidney ailments, and worms, Diuretic, and eliminating uric acid. Local stimulant for indolent ulcers; other ingredients of carrot lower blood sugar; hence carrot might be increased to good advantage in the prevention of cancer, diabetes, dyspepsia, and gout, possibly heart disease.

(ii) STEM VEGETABLES

A-POTATO

Botanical name: *Solanum tuberosum*
Hindi name: Alu or Aaloo
Family: Solanaceae
Part used: Edible part is modified stem (globose berry).

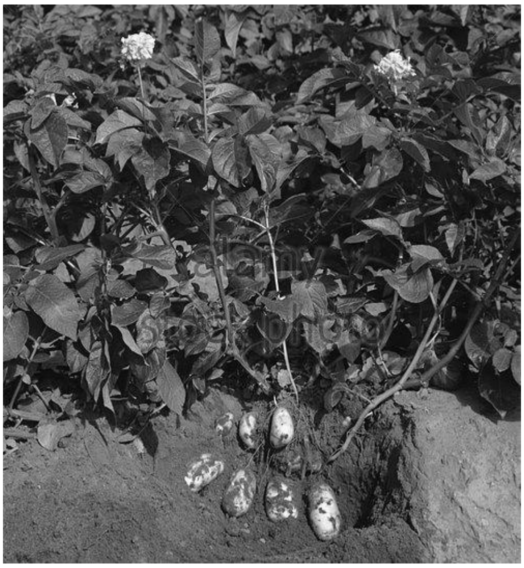


Fig.1.16- ***Solanum tuberosum*** **(Potato)**

1. Potato plants are herbaceous perennials that grow about 60 cm high, depending on variety, with the leaves dying back after flowering, fruiting and tuber formation. Leaves alternate, imparipinnate, short-stalked, Flowers white or blue, pedunculate in lateral, many flowered cymes, Fruit is a globose 2-celled berry, many-seeded, yellowish green.
2. Potato is an important cash crop which gives ready cash to farmers. It is said to be 'complete food' as it contains carbohydrates, proteins, vitamin B and C and minerals like P, Ca and Fe required for body growth.
3. It is one of the major vegetable crops of the world, richest source of starch, calorific value is high.
4. It produces more food per unit area than any cereal crop within short period. In India it is used as vegetable alone or mixed with other vegetables. Various products prepared form potato are chips, finger chips, cubes, flour etc.

B-ONION

Botanical name: *Allium cepa*
Hindi name: Kanda, Pyaz
Family: Liliaceae/ Amaryllidaceae
Part used: Edible parts are underground stems (bulbs) and leaves.

Fig.1.17-*Allium cepa* (Onion)

1. The onion is most frequently a biennial or a perennial plant, but is usually treated as an annual and harvested in its first growing season. The onion plant has a fan of hollow, bluish-green leaves and its bulb at the base of the plant begins to swell when a certain day-length is reached. The bulbs are composed of shortened, compressed, underground stems surrounded by fleshy modified scale (leaves) that envelop a central bud at the tip of the stem.

2. Onions are best cultivated in fertile soils that are well-drained. Sandy loams are good as they are low in sulphur, require a high level of nutrients in the soil.
3. Onion is the most important commercial spice crop grown in India and exported. Leaves and immature bulbs are consumed as vegetable, used for raw consumption, used in making sauce, ketch-up, pickles, and chutney. Dried onion chips and powder have great demand for export.
4. The bulbs obtained during seed production are feed to cattle or poultry. It is mixed in other vegetables and soups as spice and flavoring agent. It contains vitamins B and C and minerals Ca and Fe. It has medicinal properties and used against ear-ache, colic pain etc.

C-GARLIC
Botanical name: *Allium sativum*
Hindi name: Lasan, Lahsun
Family: Liliaceae/ Amaryllidaceae
Part used: Edible parts are leaves and bulb (cloves), it is also used in medicine.
1. This is a perennial plant with narrow flat leaves and several small bulb, known as cloves, enclosed in a white skin. It is a bulbous plant, grows up to 1.2 m (4 ft) in height. Garlic is native to the plains of western Asia.
2. Its use in cooking is as old as humanity. The bulbs are used as a condiment and flavoring substance.
3. Garlic powder is extensively used as condiment and also serves as carminative and gastric stimulant. Juice is applied in skin troubles and used as ear drop.


Fig.1.18 ***Allium sativum*** **(Garlic)**

4. It possesses anti-inflammatory, anti-arthritic, anticoagulant, hypo-proteinemic, hypocholesteremic, antibacterial, antifungal, antihypertensive and hypoglycemic action. It increases prothrombin time and fibrinolytic action. It is used in dermatophytosis, cough, febrifuge, in intermittent fever, dyspepsia. It is also used as a rubefacient, hepatoprotective and anti-androgenic.

(iii) FRUIT VEGETABLES
A-TOMATO
Botanical name: *Solanum lycopersicum*
Hindi name: Tamatar
Family: Solanaceae
Part used: Edible part is fruit.

1. The species originated in Central and South America. The plant is short lived, Perennial & annual plant, erect, aerial, woody below and


Fig.1.19 ***Solanum lycopersicum*** **(Tomato)**

herbaceous above, cylindrical with distinct ribs, solid, branched, green, Flower are small and yellow Fruit are many seeded berry.

2. Fresh ripe fruits are refreshing and appetizing and are consumed raw in salads or after cooking.

3. Unripe fruits are cooked and eaten; they are considered culinary vegetables, being ingredients of savory meals. Large quantities of fruits are canned, consumed also in the form of juice, paste, ketchup, sauce, soup and powder.

B-BRINJAL (Egg plant)

Botanical name: *Solanum melongena*
Hindi name: Baingan or Baigun
Family: Solanaceae
Part used: Edible part is fruit, whereas roots are used in medicine.

Fig.1.20 ***Solanum melongena*** **(Brinjal)**

1. It is an annual herbaceous plant, under shrub, erect, aerial, woody below and herbaceous above, cylindrical with distinct ribs, solid, branched, green, flower white or pinkish in colour, Fruit are large, ovoid, whitish or purple many seeded berry.

2. The fruits are given as culinary vegetable, usually cut into slices and fried or boiled. Besides being consumed as a vegetable, it is also pickled; sliced fruits are dried and stored.

3. It is rich in iodine contents, they are given in liver complaints; they stimulate interhepatic metabolism of cholesterol. Aqueous extract of fruits inhibit choline esterase activity of human plasma.

4. It contains higher percentage of vitamin B2 than other vegetables. The roots are antiasthmatic and general stimulant; juice use in ulcer of nose. Seeds yield fatty oil.

C-LADY'S FINGER (Okra)

Botanical name: *Abelmoschus esculentus*
Hindi name: Bhindi
Family: Malvaceae
Part used: Edible part is flower, fruit, young pod and stalk, whereas seeds are used in medicine.

Fig.1.21 ***Abelmoschus esculentus*** **(Okra)**

1. It is a native of tropical Africa, now cultivated throughout India. The plant is a stout annual. The young pods are mucilaginous.

2. The fruit are used as vegetable. It can also be dried and canned. The stalks are sometimes used for making fibers. Tender pods are also used for thickening soups and gravies whereas flowers are

eaten in soups.

3. Ripe seeds roasted for use as coffee substitute, also used in curries and chutneys. Seed are rich in protein; they are powdered and mixed with maize flour. Seed yield a fatty edible oil.

4. A vegetable gum, called okra gum is obtained from the plants, and used as combined flavoring and bodying agent in vegetable soups and gravies.

5. Immature capsule are emollient, demulcent and diuretic, seeds are stimulant, cordial and antispasmodic. The leaves yield essential oil, seed cake rich in protein.

1.3.5. FRUITS

Morphologically a fruit is the seed-bearing portion of the plant, and consists of the ripened ovary and its contents. Simple fruits are derived from a single ovary, and compound fruits from more than one. The aggregate fruits are derived from numerous carpels of the same flower, while composite fruits develop from ovaries of different flowers. In economic botany only those fruits are considered which are usually eaten without cooking. For convenience the fruits have been divided into two groups, tropical fruits (e.g. mango, citrus fruits, litchi, banana, plum, peach, guava, sugar apple, fig, papaya, pine-apple etc.) and temperate fruits (e.g. apple, pear, plum, peach, strawberries, grape, etc.).

A-MANGO

Botanical name: *Mangifera indica*

Hindi name: Aam

Family: Anacardiaceae

Part used: Edible part is fruit whereas leaves used in medicine.

Fig. 1.22 *Mangifera indica* (Mango)

1. It is the most popular and important fruit crop of India and occupying about 60% of the total area under fruits. It is one of the most highly prized dessert fruit of the tropics.

2. Mangoes thrive in all parts of India where temperature as high as 115-120°F prevail during summer. It thrive in a wide variety of soils. It grows in rich clayey loams, as well as in poor sandy and gravelly soil, provided it is fairly deep and well drained.

3. Young and unripe fruit usually acidic and used in pickles, chutney, *amchur* and culinary preparations. Ripe fruits are preserved by canning or used in the manufacturing of juice and squash, jam and jellies, preserve as *murabba* and *ampapur*.

4. It has a rich, luscious, aromatic flavor and a delicious taste in which sweetness and acidity are blend delightfully. Sucrose, glucose, fructose and maltose are present in ripe mango. Unripe fully developed mangoes of pickling varieties contain citric, malic, oxalic, succinic and two unidentified acids. Ripe fruits constitute a rich source of vitamin A.

5. Mango leaves are very useful for managing diabetes. The tender leaves of the mango tree contain tannins called anthocyanidins that may help in treating early diabetes.

B-APPLE
Botanical name: *Malus pumila*
Hindi name: Seb
Family: Rosaceae
Part used: Edible part is fruit.

Fig.1.23-*Malus pumila* (Apple)

1. Apple occupies the most important position among the fruits of temperate regions and is widely cultivated in many parts of the world. In India apple is a commercial crop in the hilly areas of Kashmir, Kulu, and Kumaon.
2. The apple plant is essentially suited to regions which have a low winter temperature, attended by snowfall. It thrives best in well drained medium loam, but it has been successfully grown on a variety of soils ranging from the deep fertile loams of Kashmir to the light loams of Kulu valley and the brown or reddish brown sandy loams of Kumaon.
3. Apple is valued mainly as dessert fruits. Fruits may be preserved for later use after slicing and drying; they are also canned and jams and jellies are made from them.
4. The juice extracted from the fruits is used fresh or after fermentation into cider wine and vinegar; apple brandy is obtained by distilling cider.
5. Apple is rich in pectin and is useful in diarrhea. Apple murabba, a preserve popular in India, is regarded as a stimulant for the heart; it is reported to relieve physical heaviness and mental strain.
6. Apple is considered a good source of potassium also it contains Ca, Mg, K, Na, P, Cl, S and Fe. The mineral constituents of apple are considered valuable for human nutrition.

C-BANANA
Botanical name: *Musa paradisiaca*
Hindi name: Kela
Family: Musaceae
Part used: Edible part is fruit.

Fig.1.24 - *Musa paradisiaca* (Banana)

1. The banana is one of the tallest herbs. The tree-like stem is composed of the sheathing spiral leaf bases. At the top of stem there is a crown produced of large oval deep-green leaves. The leaves are up to 12 feet in length and 2 feet in width, with a prominent midrib.
2. It is very ancient plant and a native of India and Malaya. It is grown in the place where the climate is warm, humid and rainy. Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, West Bengal, Bihar, Assam, Maharashtra and coastal areas are ideal for growing banana.

3. The fruits when ripped are edible. They have a high content of carbohydrates with some fats and proteins. Their food value is three times that of wheat. Green bananas may be cooked and eaten as vegetable.
4. Fruit pulp is dried and made into flour, used also for jams and jellies, sugar coated chips and several Indian confections.
5. It makes a fair source of minerals and vitamins particularly of B group. Peels are also used as cattle feed. Banana fruit is laxative and used in intestinal disorders, uremia, nephritis, hypertension and other vascular diseases.

D-LITCHI
Botanical name: *Litchi chinensis*
Hindi name: Lichi
Family: Sapindaceae
Part used: Edible part is fruit.
1. It is a medium-sized evergreen tree, with alternate pinnate leaves, with 2-8 lateral leaflets; the terminal leaflet is absent, flowers are small, greenish-white or yellowish-white, produced in panicles, and fruit is a drupe.
2. The edible flesh consists of a highly developed aril enveloping the seed. The centre contains a single glossy brown nut-like seed. Fleshy, sweet arils covering the seeds are delicious; they are eaten as such or canned.

Fig.1.25- *Litchi chinensis* (Litchi)

3. Ingested in moderate amounts, the litchi is said to relieve coughing and to have a beneficial effect on tumors and enlargements of the glands.
4. Litchi contains important phyto-chemical named Oligonol, which seems to be having features like anti-oxidants and anti-influenza. A tea of the fruit peel is taken to overcome smallpox eruptions and diarrhoea.
5. For successful cultivation the following requirement are considered essential- humid atmosphere, freedom from injurious frosts, abundance of soil moisture and deep loamy soil. The soils of litchi growing areas in Bihar and U.P. are rich in lime.

E-CITRUS FRUITS
(a) ORANGE (Mandarin)
Botanical name: *Citrus reticulata*
Family: Rutaceae
Hindi name: Santra
Part used: Edible part is fruit.
1. Mandarin is a small, evergreen tree with axillary thorns, growing 3 - 8 meters tall. A very popular fruit, widely available in countries around the world.

Fig.1.26- *Citrus reticulata* (Orange)

2. Three main climates are suitable for commercial citrus production - tropical climates, subtropical with winter rain. This species grows better in the subtropics than in the tropics.
3. In India it is cultivated in Khasi hills, Darjeeling, Garhwal, Dehradun, Sikkim, Tripura, Himachal Pradesh, Punjab, Tamil Nadu and Maharashtra.
4. The fruit is eaten as raw or cooked in puddings, cakes, confectionery etc, it is delicious, rich in vitamin C. The essential oil is distilled mainly used in confectionery, Pharmaceuticals and toilet preparations.
5. The fresh fruit is also used in salads, desserts and main dishes. The peel is used fresh, whole or zested, or dried. It can be used as a spice for cooking, baking, drinks, or candy.
6. Mandarins have also been used in Ayurveda. In traditional Chinese medicine, the dried peel of the fruit is used to treat abdominal distension, to enhance digestion, and to reduce phlegm.
7. They are rich in vitamin C, flavonoids, acids and volatile oils. The fruit is antiemetic, aphrodisiac, astringent, laxative and tonic. The seed is analgesic and carminative. It is used in the treatment of hernia, lumbago, mastitis and pain or swellings of the testes.

(b) PUMMELO (Pomelo)

Botanical name: *Citrus grandis* (*C. maxima*)
Hindi name: Chakotra
Family: Rutaceae
Part used: Edible part is fruit. Leaves and peel are also used in culinary.

Fig.1.27- *Citrus grandis* (Pomelo)

1. Fruit is usually a pale green to yellow when ripe (but also pink or red), with sweet flesh and thick spongy rind. It is the largest citrus fruit.
2. The peel is sometimes used to make marmalade, or candied then dipped in chocolate. Also used in Chinese cooking or candied. In general, citrus peel is often used in southern Chinese cuisine for flavoring, especially in sweet soup desserts.
3. Fruits are esteemed for deserts, made into jams and considered nutritive and refrigerant.
4. Leaves used in epilepsy, cholera, and convulsive coughs.

(c) LEMON

Botanical name: *Citrus limon*
Hindi name: Nimbu
Family: Rutaceae
Part used: Fruit and lemon zest.

Fig.1.28-*Citrus limon* (Lemon)

1. It is a species of small evergreen tree in the flowering plant family Rutaceae, native to Asia.
2. Lemons are a rich source of vitamin C, and contain numerous phytochemicals, including polyphenols, terpenes, and tannins. As with other

citrus fruits, they have significant concentrations of citric acid.
3. Fruit is used for culinary and non-culinary purposes throughout the world, primarily for its juice, which has both culinary and cleaning uses.
4. The pulp and zest are also used in cooking and baking.
5. The juice of the lemon is about 5 to 6% citric acid, which gives a sour taste. The distinctive sour taste of lemon juice makes it a key ingredient in drinks and foods such as lemonade and lemon meringue pie.
6. The antibacterial and immune stimulant properties of lemon have led to many medicinal uses, treating scurvy, preventing colds and flu, relieving stress and fatigue.

1.4 IDENTIFICATION

Identification is the process of matching a specimen plant to a known taxon. It uses various methods, most commonly dichotomous keys or multi-access keys. Plant identification has evolved over hundreds of years and depends to a large extent on what criteria and whose system is used. Plant identification implies comparisons of certain characteristics and then assigning a particular plant to a known taxonomic group, ultimately arriving at a species or infra-specific name. Taxonomy is the branch of botany which deals with plant identification, nomenclature and classification. You have to observe the qualities of the unknown, but to do that accurately, you need a identification key and when you are using a key-you need to know some plant basics- the difference between perennial and annual plants, for example, and some general information about plant parts- flowers, leaves, roots, seeds, and fruit.

A typical dichotomous key for plant identification, which presents a series of choices to narrow down the search. If it is woody, is it a tree, a shrub, or a woody vine. If it is a tree, is the leaf arrangement opposite or alternate, are the leaves compound or simple, do the leaves have entire margins, or are they serrated, and so on. A plant detective can make a lot of progress with this line of questioning up to a point, "but a botanist's life starts getting difficult at the species level, because you have to use flowers and fruit to distinguish between species. The vegetative features (leaves, needles) of plants are not very characteristic at higher levels of classification. There will always be difficult specimens, especially if they are sterile," that is, without flowers and fruits.

The ability to identify a plant is important for several reasons. From a vegetation management perspective, it is important to know a plant’s identity to determine if it is a weed and the level of risk it poses to desired vegetation. Identification is especially important for early detection of new weeds that have never been documented in an area before and can be targeted for eradication. Plant identification is also important for people who raise livestock and are concerned about their animals eating toxic plants. In addition, many people are interested in harvesting edible plants from the wild or their garden and yard. Knowing what plant you are about to eat could become a matter of life or death.

Plant identification can be challenging and even intimidating for the inexperienced. Many people are not comfortable using a dichotomous key and grow weary thumbing through a guidebook page by page until they happen to find a picture that looks similar to the plant they want to identify. However, looking at just a few morphological features of a plant can help you narrow down the options or even identify the plant to genus and species.

1.5 COLLECTION

Field work is one of the most essential part in the Botanical study. It permits to come across many types of plants, otherwise not seen and available in the laboratory. It is, therefore, advisable to go round many localities and explore their vegetation. Organized excursions or outings, led by experienced persons, add to the knowledge of common plants in nature. While on a collection trip, local or outstation, following things are to be carried along.

1. Containers: For packing the collected material, preferably carry plastic unbreakable containers or polythene bags.

2. Preservatives: Formalin-Acetic-Alcohol (FAA) or Alcohol 70% or Alcohol 90%, and/or Formalin 6%-10%.

3. Other requirements: Scalpel knife, blade, forceps, pencil, paper, a hand lens, a bag or vasculum for keeping plants or plant press with many newspapers or blotting papers.

After collecting the plant, it should be immediately killed and preserved or pressed to avoid its rotting and dehydration. Plants -are either sprinkled or immersed with a little of the killing agent at the spot. On return to the laboratory collected material should be transferred to new and suitable containers with fresh preservative. The plants should be completely immersed in the preservative. A few plants e.g., different parts of gymnosperms and angiosperms if collected in large quantities, are preserved in containers. But if materials are collected in lesser quantities a herbarium sheet is prepared. Even if large quantity of such plants is available, one plant with fertile parts is preserved in the form of a herbarium sheet, while others should be packed in Cl container. Every tube should be labeled. It is desired to write the name of the specimen, place and date of collection. The place of collection and date should also be written on a small piece of white card with a pencil, on the spot and inserted in the container. On return to laboratory, material is identified with the help of standard books. A label bearing mime of the division and class to which the material belongs, the name of the material, date and place of collection and also the name of student is pasted on the container.

1.6 MAINTENANCE

Herbarium is the collection of dried plant specimen, mounted on sheets. Freshly-picked specimen are dried and pasted on mounting paper of regulation-sized herbarium sheets. The purpose of such a collection is to study the vegetation of a locality and maintain its record. Collected plants are placed in the collecting sheets. The most practical size is 16.5 x 23 inches; when folded 16.5 x 11.5 inches. Old newspapers serve this purpose to an appreciable extent and a large supply should always be included in the kit.

A specimen collected should represent root, stem, leaves' and flowers. The plants are placed between the sheets or newspapers in such a way that relation between different organs is maintained. Herbaceous plants, 2 feet or less higher, may be collected entire. These can be bent to V or N shape whenever necessary. The most desirable is to collect a branch, about one foot high, containing leaves and flowers. In cases, where entire plant or branch cannot be folded to the size of herbarium sheet, only reproductive and fruiting parts and a stem with a few leaves are collected. Delicate reproductive parts collapse even if pressed fresh. These can be pressed perfectly by applying bits of moist paper to the fresh reproductive structures and spreading them when plants are placed in the press. If parts of the herbaceous plant are thick and difficult to dry, split them before placing on the collecting sheet.

Water plants collapse if dried by usual method. These should be rolled up in wet paper when in the field and brought to the laboratory. On return to the laboratory, these plants are placed in water and floated out on sheets of white paper. The sheets are taken out of water carefully, so that the various parts do not cohere. The white sheets are placed in the blotting paper and then dried as usual. After specimen has been collected and placed in collecting sheet, it is kept in plant press. This collecting sheet be placed in between blotting papers, one on either side. While on collection it is important to note date, locality, habitat, height, method of branching, colour of reproductive parts, common name, etc. This should be noted separately in a field-book.

1.7 SUMMARY

Economic botany is the study of the relationship between people (individuals and cultures) and plants. Economic botany intersects many fields including established disciplines such as - Agronomy, Anthropology, Archaeology, Chemistry, Economics, Ethno Botany, Ethnology, Forestry, Genetic Resources, Geography, Geology, Horticulture, Medicine, Microbiology, Nutrition, Pharmacognosy, and Pharmacology. This link between botany and Anthropology explores the ways humans use plants for food, shelter, medicines, textiles, and more. Plants are extremely important in the lives of people throughout the world. People depend upon plants to satisfy such basic human needs as food, clothing, shelter, and health care. These needs are growing rapidly because of a growing world population, increasing incomes, and urbanization.

The cereals are the members of Gramineae family, and possess the characteristic fruit, the caryopsis. There are six true cereals of which rice, wheat and maize, are most important cereals and they played a crucial part in the development of human civilization. Cereals contain a high percentage of carbohydrates, together with a considerable amount of proteins and some fats. The Legumes are next in importance to cereals as source of human food. They contain more proteins than any other vegetable product. The legumes have been cultivated and used as a food for centuries all over the world. The vegetables rank next to cereals as sources of carbohydrate food. The nutritive value of vegetables is incredible, due to the presence of indispensable mineral salts and vitamins. Vegetables store up reserve food in roots, stem, leaves and fruits, which are eaten raw, cooked and as salad. The storage organs may be true roots or modified stems, such as rootstock, tubers, corms and bulbs. A fruit is the seed-bearing portion of the plant, and consists of the ripened ovary and its contents. In economic botany only those fruits are considered which are usually eaten without cooking.

1.8 GLOSSARY

Aleurone: protein granules (aleurone grains) found in a single layer of cells (aleurone layer) in the outermost portion of the endosperm.
Arid: (of land or a climate) having little or no rain; too dry or barren to support vegetation.
Bagasse: is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice.
Bulbs: any round, enlarged part, especially at the end of a cylindrical object.
Calorific: relating to the amount of energy contained in food or fuel.
Canned: preserved in a can or jar.
Caryopsis: a small, one-celled, one-seeded, dry indehiscent fruit with the pericarp adherent to the seed coat, the typical fruit of grasses and grains.
Catecholamine: any of a group of chemically related neurotransmitters, as epinephrine and dopamine, that have similar effects on the sympathetic nervous system.
Chard: a variety of beet, Beta vulgaris cicla, having leaves and leafstalks that are used as a vegetable.
Confectionary: a place where confections are kept or made; a candy; sweetmeat.
Convalescence: the gradual recovery of health and strength after illness.
Cordate: (of leaves) heart-shaped, with the attachment at the notched end.
Culinary: of, relating to, or used in cooking or the kitchen.
Cymes: an inflorescence in which the primary axis bears a single central or terminal flower that blooms first.
Dextrin: are a group of low-molecular-weight carbohydrates produced by the hydrolysis of starch or glycogen.
Drupe: any fruit, as a peach, cherry, plum, etc., consisting of an outer skin, a usually pulpy and succulent middle layer, and a hard and woody inner shell usually enclosing a single seed.
Embryo: the rudimentary plant usually contained in the seed.
Endosperm: nutritive matter in seed plant ovules, derived from the embryo sac.
Euphoria: a state of intense happiness and self-confidence.
Foliage: the leaves of a plant, collectively; leafage.
Glabrous: having a surface devoid of hair or pubescence.
Glazed: having a surface covered with a glaze; lustrous; smooth; glassy.
Globose: having the shape of a globe; globelike.
Hulls: the husk, shell, or outer covering of a seed or fruit.
Husk: the dry external covering of certain fruits or seeds, especially of an ear of corn.
Imparipinnate: pinnately compound leaves in which there is a lone terminal leaflet rather than a terminal pair of leaflets; also called "odd-pinnate".
Indispensable: absolutely necessary, essential
Inflorescence: the arrangement of flowers on the axis.
Kernels: the softer, usually edible part contained in the shell of a nut or the stone of a fruit, or the body of a seed within its husk or integuments.
Kharif: (in India) a crop sown in early summer for harvesting in the autumn.

Linoleum: a material consisting of a canvas backing thickly coated with a preparation of linseed oil and powdered cork, used especially as a floor covering.
Livestock: the horses, cattle, sheep, and other useful animals kept or raised on a farm or ranch.
Loamy: a rich, friable soil containing a relatively equal mixture of sand and silt and a somewhat smaller proportion of clay.
Molasses: a thick syrup produced during the refining of sugar or from sorghum, varying from light to dark brown in color.
Monoecious: having the stamens and the pistils in separate flowers on the same plant.
Panicle: a compound raceme, or any loose, diversely branching flower cluster.
Peduncle: a flower stalk, supporting either a cluster or a solitary flower.
Perceptible: capable of being perceived; recognizable; appreciable.
Pinnate: (of a leaf) having leaflets or primary divisions arranged on each side of a common stalk.
Potherb: any herb prepared as food by cooking in a pot, as spinach, or added as seasoning in cookery, as thyme.
Procumbent: (of a plant or stem) lying along the ground, but not putting forth roots.
Prothrombin: a plasma protein involved in blood coagulation that on activation by factors in the plasma is converted to thrombin.
Rabi: the grain crop sown in September and reaped in the spring.
Ripen: to bring or come to maturity, the proper condition, etc.; mature.
Rosette: a circular cluster of leaves or other organs. Any arrangement, part, object, or formation more or less resembling a rose.
Rubefacient: causing redness of the skin, as a medicinal application.
Sautéed: cooked or browned in a pan containing a small quantity of butter, oil, or other fat.
Spikelet: the basic unit of a grass flower, consisting of two glumes or outer bracts at the base and one or more florets above.
Staple food: is a food that is eaten routinely.
Trifoliate: (of a compound leaf) having three leaflets.
Zest: is a food ingredient that is prepared by scraping or cutting from the outer, colorful skin of unwaxed citrus fruits such as lemon, orange. Zest is used to add flavor to foods.

1.9 SELF ASSESSMENT QUESTION

1.9.1 Short answer type question:

1. What type of fruit is present in wheat?
Ans. Caryopsis.

2. Which part of mango fruit is edible?
Ans. Mesocarp

3. Orange fruits are rich sources of-

Ans. Citric and malic acid

4. The edible part of potato is
Ans. Modified stem

1.9.2 Multiple choice questions:

1. Major food crops of the world belongs to the family-
(a) Leguminosae (b) Solanaceae
(c) Cruciferae (d) Gramineae

2. Pulses are important source of
(a) Proteins (b) carbohydrate
(c) Fats (d) sugar

3. Mango is a fruit of -
(a) Temperate (b) Sub- tropical
(c) Tropical (d) None of the above

4. Banana is propagated by-
(a) Suckers (b) Rhizome
(c) Seed (d) Stem cutting

5. Potato is a modified
(a) Stem (b) Root
(c) Leaves (d) Fruit

6. Onion crop is
(a) Annual (b) Biennial
(c) Perennial (d) None of the above

7. Which one of the following is the pseudo cereal?
(a) *Zea mays* (b) *Oryza sativa*
(c) *Triticum aestivum* (d) *Fagopyrum esculantum*

1.9.3-Fill in the blanks

1. The scientific name of brinjal__________________
2. Food grains which provide the most important staple food for mankind are______________
3. The botanical name of bajra is_________________
4. Banana fruit is a rich source of___________________
5. The botanical name of orange is______________________
6. Gram pea is dry crop grown is ____________________season.
7. ____________ are the edible part of beetroot.

8. In maize then food stored in_______________
9. _________________is the botanical name of Garlic.
10. Pulses belongs to the family_______________

1.9.2 Answers Key: 1-(d), 2-(a), 3-(c), 4-(b), 5-(a), 6-(b), 7-(d)

1.9.3 Answers Key: 1-*Solanum melongena*, 2-cereals, 3-*Pennisetum glaucum*, 4-Vitamin A and C, 5-*Citrus reticulata*, 6-Rabi season, 7-Roots, 8-Endosperm, 9-*Allium sativum*, 10-Fabaceae

1.10 REFERENCES

- Kochhar S.L.,1998, *Economic botany in the tropics*, Macmillan pub.
- Pandey B. P., 2012, *Economic Botany,* S. Chand publication.
- Nivedita Srivastava , 2014, *Medico Botany of Garhwal Himalayas*, Deep pub.
- Mangold J., Parkinson H., 2013, *Plant Identification Basics,* Department of Land Resources and Environmental Sciences.
- www.flowersofindia.net
- www.plants.usda.gov
- www.indianmedicinalplants.com
- www.biologydiscussion.com
- www.odishafdc.com
- www.dictionary.com

1.11 SUGGESTED READINGS

- Kochhar S. L., *Economic Botany: A Comprehensive Study*, 5th Edition, 2016.
- Maheshwari, P. & Singh, U. *Dictionary of Economic Plants in India*, I.C.A.R. New Delhi, 1965.
- Sammbamurty, *A Textbook of Modern Economic Botany*.
- Mangold J., Parkinson H., 2013, *Plant Identification Basics*, Department of Land Resources and Environmental Sciences.
- S. Sen., 2009, *Economic Botany*.
- John H. Wiersema, Blanca León, *World Economic Plants: A Standard Reference*, Second Edition.
- Hill, A.F. Economic Botany; *A Textbook of Useful Plants and Plant Product*. McGraw-Hill Book Co., New York, 2nd Ed. 1952.
- Bailey, L.H. *Manual of cultivated plants*. The Macmillan Co., New York, 1949

1.12 TERMINAL QUESTIONS

1. Describe the morphological features of Sweet Potato and Beetroot. Discuss their economical role.
2. Write a short note on cereals. Give an account on wheat and rice cereals crops.
3. Give a detailed account on economic importance of pearl millet.
4. Write a short note on Sugar and Starch. Describe their role as an important crop in India.
5. Describe the commercial and economical importance of Legumes. Discuss the any two legume crops.
6. What are underground vegetables? Write about the characteristics of Radish and Carrot.
7. Write about the economical importance of fruit vegetables. Discuss detailed features of Tomato and Brinjal.
8. Write a short note on the economic importance of the following:

a. Mango b. Lemon c. Banana

UNIT-2 STUDY THE ECONOMICALLY IMPORTANT PLANTS AND PLANT PRODUCT; THEIR COLLECTION, AND IDENTIFICATION –II

Contents

2.1 OBJECTIVES

After reading this unit student will be able-

- To describe the economical importance of various plants and plant products.
- To understand the identification, collection and maintenance of given plants

2.2 INTRODUCTION

The economic botany deals with application of botanical knowledge to the well being of mankind. Plants fulfill three major needs of human life viz., food, clothing and shelter. Most of the useful articles are also plant conversion products. Plants yield fibers, wood, drugs, beverages, oils, cellulose, fats, latex, fumitories, masticatories, spices, tannins, dyes, latex, gums, etc.. The food primarily comes from plants in the forms of cereals, millets, pulses, vegetables and fruits. For clothing, again plants are indispensable. The plants that yield fibers are second only to food plants. Man needed some form of clothing, and this need was fulfilled only by fiber yielding plants. In this respect, cotton occupies an important position, supplemented by jute and some other fiber for coarse clothing. The most familiar and important plant product is wood, which is used in all types of construction work. It becomes quite evident that knowledge of botany and its proper application led to the well-being of humanity in several ways. It becomes quite evident that knowledge of botany and its proper application led to the well-being of humanity in several ways. Some of the important plants and their uses are described in this chapter.

Practical Work

The plants of economic importance are kept in the laboratory as specimen, a student is expected to study their characters, identify the plant and the useful plant parts. The student should also be informed about different uses of the plant, cultivation, production and marketing statistics, etc. Therefore, comments written in practical record should include the following sequence.

1. Botanical name of the plant
2. Common English or Hindi name / vernacular name
3. Family
4. Part/parts of the plant used
5. Characters of the plant/ plant part
6. Cultivation, harvesting and processing
7. Uses of the plant part/ parts
8. World production/ Production in India

Practical record should also include diagrams of typical plant or plant part which is economically useful.

2.3 ECONOMICALLY IMPORTANT PLANTS AND PLANT PRODUCTS-II

2.3.1 TIMBERS

Prior to a tree being harvested (logged), timber is the term most often used. Other industries generally refer to timber as the product ready for making something. For example, wood that is suitable for carpentry and building houses is called timber. Timber is a type of wood that has been processed into beams and planks, a stage in the process of wood production. It is commercially used in many purposes such as in making furniture's, construction work, frames, doors, windows, boats, railway sleepers etc.

A-SISSOO

Botanical name: *Dalbergia sissoo*
Hindi name: Shisham
Family: Papilionaceae
Part used: Part of the plant used is heartwood which is a valuable timber.


Fig. 2.1 - *Dalbergia sissoo* (Sissoo)

Description

1. It is a large tree reaching a height of 30 m and a girth of 2.4 m.
2. The heartwood is brownish in colour with darker streaks. It is hard and moderately heavy to very heavy.
3. It is diffuse porous. Growth rings are indistinct and ripple marks are present.
4. The wood can be seasoned without much difficulty. It can last for about 288 months.
5. The tree occurs throughout the sub-Himalayan tract from Indus to Assam. It has also been extensively cultivated in many parts of the country especially Punjab, U.P., West Bengal and Assam.
6. Shisham is very commonly used for building purposes, furniture, carriages, carving, etc.

B-SAL

Botanical name: *Shorea robusta*
Hindi name: Sal, Sakhu
Family: Dipterocarpaceae
Part used: Part of the plant used is heartwood which is a valuable timber.

Description

1. It is a large deciduous tree reaching a height of about 37 m (up to 46 m) and a girth of about 3.7 m.
2. The sapwood and heart wood are distinct. The sapwood is white with brownish tinge and heart wood is brown to reddish brown. The wood is dull hard to very hard and usually heavy to very heavy.
3. It is diffuse porous to ring porous. The annual rings are indistinct to absent. Ripple marks are normally absent.

Fig. 2.2 - *Shorea robusta* (Sal)

4. The wood is difficult to season. It develops cracks during seasoning. It remains in good condition even after 20 years of contact with the ground.
5. This most popular wood is used as a structural timber used for doors, windows, beams, planks, etc. It is also useful as railway sleepers.

C-TEAK

Botanical name: *Tectona grandis*
Hindi name: Sagaun
Family: Verbenaceae
Part used: Part of the plant used is heartwood as timber.

Description

1. It is a large deciduous tree with outer bark peeling off in long thin flakes.
2. The wood is moderately hard, strongly and characteristically scented. It contains an oil which is easily perceptible to touch. The oil acts as preservative against white ants.

3. Heart wood is dark brown and turns almost black with age. Annual rings are distinct, marked with regularly arranged pores.

Fig. 2.3 - *Tectona grandis* (Teak)

4. Teak wood is used for construction purposes, furniture and cabinet work.
5. The tree grows in Western Ghats, Tamil Nadu, M.P., Orissa, Mysore and Bihar.

D-PINE WOOD

Botanical name: *Pinus roxburghii*
Hindi name: Chir
Family: Pinaceae
Part used: Part of the plant used is heartwood as timber.

Fig. 2.4 - *Pinus roxburghii* (Pine Wood)

Description

1. It is native to the Himalayas, and was named after William Roxburgh.
2. It is a large tree reaching 30–50 m, bark is red-brown, leaves are needle-like, in fascicles of three, very slender, distinctly yellowish green, cones are ovoid conic 12–24 cm long and 5–8 cm broad at the base when closed, seeds are 8–9 mm long, with a 40 mm wing, and are wind-dispersed.

Economic Importance

1. Source of an oleoresin which yields turpentine oil, chiefly used as a solvent for paints and varnishes; also used in perfumery industry, in the manufacture of synthetic pine oil, disinfectants, insecticides, and denaturants.
2. It is expectorant, useful in chronic bronchitis and especially recommended for gangrene of lungs. Given as a carminative in flatulent colic and also used to arrest minor hemorrhages in tooth-sockets and nose.
3. Also employed in paper and rubber industries, furniture polishes, floor waxes, shoe creams, metal polishes, and printing inks.
4. Wood used for constructional purposes, cheap joinery and furniture, packing cases, truck and bus bodies, and electric transmission poles. Also used for railway sleepers and for wagons and railway carriages.

E-DEODAR

Botanical name: *Cedrus deodara*
Hindi name: Devadar, Diar
Family: Pinaceae
Part used: Part of the plant used is heartwood as timber.

Description

1. A tall evergreen tree found in the North-Western Himalayas from Kashmir to Garhwal.
2. It is a large evergreen coniferous tree reaching 40–50 m tall, with a trunk up to 3 m in diameter, forming a typical conical crown. Branches two types, long shoots bear spirally arranged leaves, dwarf shoots bear cluster of leaves in pseudo-whorls. Flowers monoecious, male and female cones occurring on separate branches.

Economic Importance

1. It is used in Ayurvedic medicines is well recorded. The inner wood is aromatic and used to make incense. As insects avoid this tree, the essential oil is used as insect repellent.
2. It also has antifungal properties and has some potential for control of fungal deterioration of spices during storage.
3. This is strongest of Indian coniferous wood. Seasoned heartwood of deodar is very durable.

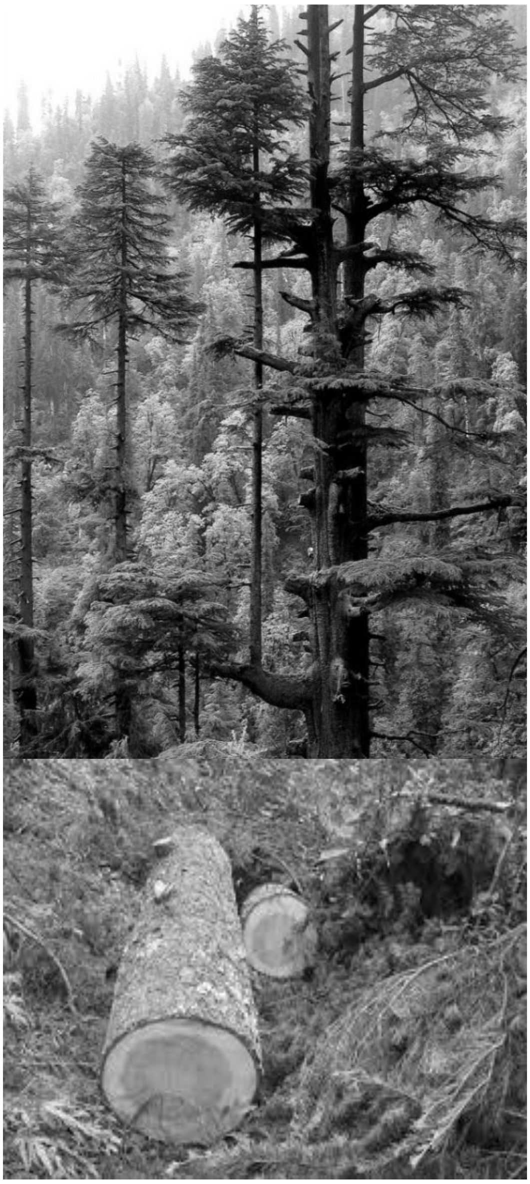


Fig.2.5-*Cedrus deodara* (Deodar)

The durability of deodar may be due to the presence of terpene/resin acids present in the heartwood.
4. The timber is used for construction work and for railway sleepers. It is also suitable for beams, floor boards, ports, window frames, light furniture and shingles.

2.3.2 BEVERAGES

The beverages containing caffeine are used all over the world for their stimulating and refreshing qualities. Caffeine is an alkaloid, which has definite medicinal value and acts as a diuretic and nerve stimulant. The important non-alcoholic beverages are - Tea, Coffee and Cocoa.

A-TEA

Botanical name: *Camellia sinensis*
Hindi name: Chai or cha
family: Theaceae
Part used: Parts of plant used are leaves which give a popular beverage called tea.

Fig.2.6- *Camellia sinensis* (Tea)

Description

1. It is a species of evergreen shrub or small tree whose leaves and leaf buds are used to produce tea. It is usually trimmed to below 2 m when cultivated for its leaves, has a strong taproot, flowers are yellow-white, 2.5–4 cm in diameter, with 7 to 8 petals.
2. It is mainly cultivated in tropical and subtropical climates, in areas with at least 127 cm of rainfall a year. Many high quality teas are grown at high elevations, up to 1,500 meters, as the plants grow more slowly and acquire more flavor.
3. Tea contains 2.5% theine, 13-18% tannin, volatile oils and a small amount of caffeine.
4. The leaves are plucked and cured and an infusion in boiled water yields most popular of the beverages.
5. India is one of the leading producers and exporters of tea. About 73% of the total output comes from south-east region, especially Assam and West Bengal.

B-COFFEE

Botanical name: *Coffea arabica*
Hindi name: Kafi
Family: Rubiaceae
Part used: Parts of the plant used are seeds which are used for the preparation of a beverage called coffee.

Description

1. Wild plants grow between 9 and 12 m tall, leaves are opposite, simple elliptic-ovate to oblong, glossy dark green. The flowers are white, and grow in axillary clusters, seeds are contained in a drupe (cherry), maturing bright red to purple and typically contains two seeds (the coffee beans). The plant grows in hot, moist climate. These are raised from seeds or seedlings and come into bearing in the third year.
2. The fruits are berries and the skin is removed. The seeds are then roasted to develop aroma, flavor and colour. Seeds contain 0.75 to 1.5% caffeine, a volatile oil caffeol, glucose, dextrin, proteins and fatty oils.
3. It is a source of 90% of the world supply. Brazil tops the world production. U.S.A. leads in per capita consumption.
4. In India, coffee is cultivated in Karnataka, Tamil Nadu and Kerala.

(A) **(B)**

Fig.2.7 (A) *Coffea arabica* (Coffee), (B) Coffee Beans

C-COCOA

Botanical name: *Theobroma cacao*

Common name: Cocoa

Family: Malvaceae

Part used: Plant part used are fruit seeds (cocoa beans)

Fig.2.8-*Theobroma cacao* (Cocoa)

Description

1. A small tree, grows to 50 ft., it require constant warmth and rainfall to thrive. The cocoa tree is native to the America, but now cultivated along the Malabar Coast and in the Nilgiris and Pulney hills. It is grown throughout tropical South and Central America, West Indies, and many other parts of

the world.
2. Its seeds, cocoa beans, are used to make cocoa mass, cocoa powder, confectionery, ganache and chocolate (which is obtained by roasting and grinding the seeds).
3. The seed contain less than 1 percent of an alkaloid, theobromine, with a few traces of caffeine, is responsible for the stimulating properties.
4. Chocolate is also said to contain the chemical Phenyl ethylamine, a natural amphetamine found in the human brain, which induces a feeling of euphoria.

2.3.3 OILS

The term "plant oils", we refer to oils that are derived from one or more parts of a plant, shrub or tree. Hence the oil could be from the root, stem/bark, leaves, flowers, seeds, fruits and whatever else could be a part of the plant. Oils, oleoresins & extracts from plants are used in a wide variety of ways – in food, as medicine, in cosmetics & toiletry, as ingredients for industrial products, as fuel, and more. Essential oils are volatile, and are usually derived from the non-seed parts of the plants. Most fixed oils are the so-called "fatty oils", and a majority of the fatty oils are derived from the seeds, hence the term oilseeds, meaning oil-bearing seeds. Some of the fixed oils are derived from vegetables & nuts.

A-GROUNDNUT

Botanical name: *Arachis hypogaea*
Hindi name: Moongphali
Family: Fabaceae ⁄ Leguminosae
Part used: Part of the plant used are seeds from which oil is extracted.

Description

1. Peanut is an annual herbaceous plant growing 30 to 50 cm, leaves are opposite and pinnate with four leaflets
2. It is widely grown in the tropics and subtropics, grow best in light, sandy loam soil with a pH of 5.9–7 being important to both small and large commercial producers.
3. It is classified as both a grain legume and, because of its high oil content, an oil crop. Peanuts harbor symbiotic nitrogen-fixing bacteria in root nodules. Seeds are an important source of vegetable non-drying oil.
4. Peanuts have a variety of industrial end uses. Paint, varnish, lubricating oil, leather dressings,

Fig.2.9- ***Arachis hypogaea*** **(Groundnut)**

furniture polish, insecticides, and nitroglycerin are made from peanut oil. Soap is made from saponified oil, and many cosmetics contain peanut oil and its derivatives.

5. The protein portion is used in the manufacture of some textile fibers. Peanut shells are used in the manufacture of plastic, wallboard, abrasives, fuel, cellulose (used in rayon and paper), and mucilage (glue).

6. The major ground nut producing countries are India, China, West Africa, U.S.A, etc.

B-CASTOR

Botanical name: *Ricinus communis*
Hindi name: Arandi
Family: Euphorbiaceae
Part used: Seeds of the plant used for oil extraction.

Fig.2.10- *Ricinus communis* (Castor)

Description

1. It yields one of the most important non-drying oils. The oil contents of seeds vary from 35 to 58%. It is green in colour. Oil is collected from the seeds by solvent extraction or expression.
2. Castor oil is used as purgative. Being water resistant, it is used for making fabrics, for protective covering of air-planes, insulations, etc. It is also used in soap manufacture, inks, plastics, paints, varnishes, leather preservation, etc. Oil cake is poisonous and cannot be used as cattle feed. However, it is an excellent fertilizer.
3. In India AP., Tamil Nadu, Maharashtra and Karnataka are chief castor seed growing states.

C-MUSTARD

Botanical name: *Brassica campestris*
Hindi name: Sarson
Family: Cruciferae
Part used: Part of the plant used are seeds for extraction of oil.

Fig.2.11-*Brassica compestris* (Mustard)

Description

1. It yields one of the most important edible oils. The oil content varies between 30-48%. Oil contains glycerides and erucic acid.
2. It is mostly grown along with rabi crops.
3. The seed and oil are used as condiments in the preparation of pickles and for flavoring curries and vegetables. Oil is also used in lamps, in tempering steel, in oiling wooden goods,

in making soaps, etc. The oil cake is used as a cattle feed. The leaves of young plants are used as green vegetable.

4. India is the first both with regard to acreage and production in the world. It is chiefly grown in Bihar, M.P., West Bengal, Orissa and U.P.

D-LINSEED

Botanical name: *Linum usitatissimum*

Hindi name: Alsi

Family: Linaceae

Part used: Parts of the plant used are (a) seeds for oil extraction and (b) stem for extraction of fibers.

Fig.2.12-*Linum usitatissimum* (Linseed)

Description

1. Oil. The seeds contain about 32 to 40% of drying oil which is expressed mechanically. It is chiefly used in the preparation of paints and varnishes because it dries into thin elastic film when exposed due to absorption of oxygen from the atmosphere. It is also used in the preparation of soaps, manufacture of printing ink and linoleum, oil cloth, water proof fabrics, and as edible oil in some areas. The residue oilcake is a valuable cattle feed and manure.

2. Fibers. The pericyclic fibers are separated from the stem. These are very tough, wiry strands of long and thick (cellulose) cells. Fibers possess great tensile strength, fineness and durability. It is used in the manufacture of linen cloth, thread, canvas, writing and cigarette papers and insulating materials.

3. The major linseed growing countries are U.S.A, Canada, Argentina, Russia and India.

4. In India *Linum* is chiefly grown for its oil and fibers in M.P., U. P. and Maharashtra as rabi crop.

2.3.4 FIBERS

Fiber yielding plants rank second only to food plants in their usefulness to human kind. The utilization of fibers is directly related to the advancement of civilization. They have enormous value in our daily life. The chief fibers of commercial importance have been classified in six groups- textile fibers (e.g., cotton, flax), brush fibers, filing fibers, rough weaving fibers, natural fabrics and paper-making fibers.

A-COCONUT (Coir)

Botanical name: *Cocos nucifera*
Hindi name: Nariyal
Family: Arecaceae (Palm family)
Part used: Parts of the plant used are
(a) mesocarp of the fruit for fibers and (b) endosperm of the seed for extraction of oil.

Fig.2.13- *Cocos nucifera* (Coconut)

Description

1. This tall palm tree bears fruits in bunches on the tree. The fruit is a three sided drupe consisting of a smooth rind or exocarp, a reddish brown fibrous mesocarp and a hard stony endocarp or shell enclosing the seed. The well known coconut meat and milk are actually the endosperm of the seed.
2. The fibrous husk is used for the manufacture of coir which is used for the cordage, mats, foot rugs, brushes, stuffing, etc.
3. The shells are used as containers and as fuel. The milk (watery endosperm) is a refreshing drink. The cellular endosperm is eaten raw or dried to form copra from which oil is extracted.
4. Coconut oil is used in the manufacture of margarine, vegetable ghee and hard soaps.
5. Unopened inflorescence yields palm sugar and Leaves are used for thatching.
6. Indonesia leads the production followed by Philippines, India and Sri Lanka.

B-JUTE

Botanical name: *Corchorus capsularis*
Hindi name: Pat, Titapat.
Family: Tiliaceae (Linden family)
Part used: Parts of plant used are fibers from phloem (bast fibers) of stem.

Description

1. The plant is an annual shrub and is grown from seeds. It is best grown in humid regions with moderate rains, on light, sandy, deltaic loams.
2. The fibers are obtained from the secondary phloem by retting the stem. The stems are beaten and fibers separated.

(A) (B)

Fig.2.14 (A) - *Corchorus capsularis* (Jute), (B) - Jute

3. The fiber is used for manufacturing packing cloth, hessian, bags for transport and storage, rugs, curtains, upholstery, linings, ropes, twines, etc.
4. This is the most important cash crop of north-east India, especially valleys of Ganges and Brahmaputra in Assam, West Bengal, Bihar and Orissa. About 67% of the products are consumed at home while the rest are exported to U.S.A., U.K., Australia, Canada, Argentina, etc. Other major jute producing country is Bangladesh.

C-COTTON

Botanical names: *Gossypium arboreum*
Hindi name: Kapas
Family: Malvaceae
Part used: Parts of the plant used are (a) seeds for oil extraction and (b) seed hair as cotton fibers.

Fig.2.15 *Gossypium arboreum* (Cotton)

Description

1. This plant is an important fiber and oil seed crop. Both oil and fibers are obtained from the seeds. The fibers are epidermal hair, while oil is expressed from the seeds.
2. Plant is a perennial shrub or a small tree which grows on sandy damp soil of humid regions. Black alluvial soil of the In India, Deccan plateau is considered the best.
3. Oil obtained from the seeds is used as salad and cooking oil, preparation of oleomargarine, oil residue as raw material for soap, washing powders. Oil cake is used as food for cattle.
4. The fibers are collected from seed hairs and after processing bales are made into varied products. It is an important constituent of cotton fabrics, rubber tire fabrics, carpets, blankets, cordage, etc. Raw cotton is used for stuffing.
5. Cotton is cultivated in U.S.A., India, Pakistan, Egypt and Brazil.
6. In India, it is grown in Maharashtra, Karnataka, Punjab, Assam, Gujarat, Madhya Pradesh and Uttar Pradesh.

2.3.5 MEDICINAL PLANTS

The branch of medical science, which deals with the drugs plants, is known as Pharmacognosy. Most of the drugs are obtained from wild plants growing in all parts of the world, especially in tropical regions. The medicinal value of drug plants is due to the presence in the plant tissue of some chemical substances that produce a definite physiological action on human body. The most important of these substances are alkaloids. Some of these chemicals are powerful poisons and therefore the drugs should be prepared and prescribed only by expert physicians.

A-RAUWOLFIA (Snakeroot)
Botanical name: *Rauwolfia serpentina*
Hindi name: Sarpagandha, Chandrabagha
Family: Apocynaceae (oleander family)
Part used: It is the roots of the plant that are mainly used for medicinal purposes.

Description

1. Sarpagandha is an erect, evergreen shrub, leaves are large, in whorls of three - dark green above and pale green below. The flowers are white, pinkish or red, occurring in whorls. Fruit are tiny, oval, fleshy which turn a shiny purple-black when ripe.
2. The drug consists of the dried roots with their bark intact, preferably collected in autumn from three or four year old plants.
3. It particularly belongs to India in the Sub-Himalayan tracts as well as, in the lower ranges of the Eastern and Western Ghats and in the Andaman.

Fig.2.16 -*Rauwolfia serpentina* (Snakeroot)

4. This herb is considered to be effective in lowering blood pressure and fever. It also helps in stimulating uterine contractions at the time of delivery. It has been used for millennia as an antidote against bites of venomous reptiles.
5. It has a potent anti-arrhythmic effect which used to treat high blood pressure (hypertension). It is used in insomnia and irritative conditions of the central nervous system. It causes depletion of catecholamine at the central and peripheral level and depletion of Serotonin at the central level.
6. Root is a valuable remedy for dysentery and painful affections of bowel. Decoction of root is applied to increase uterine contractions and promote expulsion of fetus. Juice of leaves is instilled in eyes as a remedy for the opacities of cornea.

B-EPHEDRA

Botanical name: *Ephedra gerardiana*
Hindi name: Asmania or Somlata
Family: Ephedraceae
Part used: Fruit is edible. Young branchlets and stems of the plant are used as a medicine.

Fig.2.17 - *Ephedra gerardiana* (Ephedra)

Description

1. It is a perennial small shrub composed primarily of fibrous stalks, generally about 8 inches, yellow flowers followed by round, red, edible fruits.
2. It is endemic to the mountains of Afghanistan, Bhutan, northern India, Nepal, Pakistan, Sikkim, Tajikistan, and Tibet.
3. It is sometimes used as a stimulant, and in Ayurvedic medicine, its tea is used as medicine for colds, coughs, bronchitis, asthma, and arthritis.
4. Its tincture is effective as a cardiac and circulatory stimulant whereas its rhizome is used as fuel by the people of Tibet. Some species are grown as ornamental plants.

C-CINCHONA

Botanical name: *Cinchona officinalis*
Common name: Quinine, Peruvian bark
Family: Rubiaceae
Part used: It is the bark of the tree that is used in herbal medicine and is sourced for drugs.

Fig.2.18 *Cinchona officinalis* (Cinchona)

Description

1. Species of cinchona are all evergreen, with waxy, dark green leaves resembling other species of the Rubiaceae family (such as coffee). They may be shrubs or trees, up to 15 m in height. The flowers are produced in panicles and may be white, red, or pink depending on the species.
2. The native range of cinchona species are the lower to mid-elevations of the Andes in South America. Cinchona is the national tree of both Peru and Ecuador. In India the habitat is mainly found to be Nilgiri Hills.
3. Its bark is an important constituent in herbal medicines and is used as a tonic and a digestive stimulant for the cure of conditions like indigestion, gastro-intestinal disorders and also as an appetite stimulant. Quinine is an anti-fever agent and is used for the prevention and cure of malaria.

4. In general, the herb can classified as an excellent analgesic, anesthetic, anti-arrhythmic, antibacterial, anti-malarial, antimicrobial, anti-parasitic, antipyretic, antiseptic, antispasmodic, antiviral, astringent, bactericide, cytotoxic, febrifuge, fungicide, insecticide, nervine, stomachic and a tonic.

D-ACONITUM

Botanical name: *Aconitum heterophyllum* wall.
Hindi name: Ativisha, Atis
Common name: Aconite, Wolfsbane, Monkshood
Family: Ranunculaceae
Part used: Dried tuberous roots.

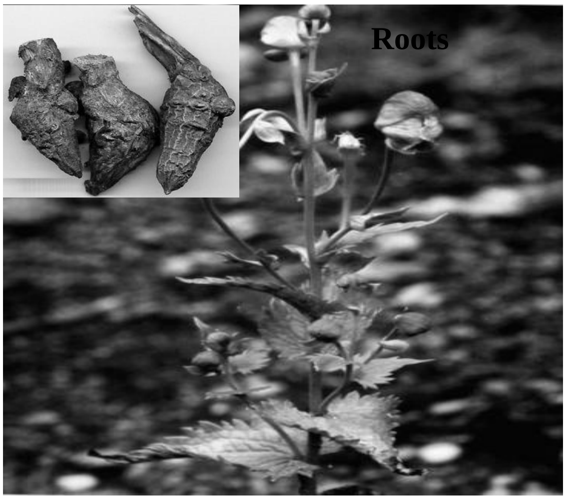


Fig.2.19- *Aconitum heterophyllum*(Aconitum)

Description

1. Biennial herb, up to 1 m tall. Lower leaves orbicular and broadly ovate, more or less 5-lobed, teeth obtuse, upper leaves clasping, lanceolate, not lobed, sharply toothed. Flowers 2-5 cm long, dull green blue with purple veins. Follicles downy; seeds many. Sparsely distributed on meadows and slopes between 2500-3500 m.
2. It is used in curing kapha and pitta. Tuberous and roots are bitter tonic, astringent, antiperiodic, aphrodisiac, useful in diarrhoea and dysentery, acute inflammation, dyspepsia, loss of memory, piles and throat disease.
3. Roots powder is useful in splenic fever and gastric troubles of children suffering from cough and vomiting.
4. Folklore- The powdered root is considered as an antidote to poison, in gastroentiric fever of the infants and children.

E-ATROPA (Deadly Nightshade)

Botanical name: *Atropa belladonna*
Hindi name: Angur Shefa, Luckmunee, Suchi
Family: Solanaceae
Part used: The roots & the leaves are the most commonly used parts for its medicinal purposes.

Description

1. Atropa is a perennial branching herb growing to 5 feet tall, leaves are dull, darkish green in colour and of unequal size, 3-10 inches long, The flowers, borne in leaf axils, are of a dark and purplish colour, tinged with green, about 2.5 cm long, pendent, bell-shaped, furrowed. The fruit is smooth berry (intensely sweet but most of their alkaloids are in the seed), which ripens to acquire a shining black or purple color.

2. It is native to temperate southern and central Europe but has been cultivated and introduced outside its native range. The species grows well in soils that have a chalky composition, it thrive in woods, on waste ground and near old ruins.

Fig.2.20- ***Atropa belladonna*** **(Atropa)**

3. The plant is believed to be narcotic, diuretic, sedative, antispasmodic, mydriatic. Belladonna is the most valuable plant in the treatment of eye diseases for atropine, obtained during extraction is an important constituent on account of its power of dilating the pupil.
4. It is used as a lotion, plaster or liniment in case of neuralgia, gout, rheumatism and sciatica. It also helps in relieving acute sore throat, local inflammation and congestion. It is powerful antispasmodic in intestinal colic and spasmodic asthma.
5. In children, it is used to treat whooping cough and false croup and also used in treating pneumonia, typhoid fever and other acute diseases.
6. It helps in dealing with peptic ulcers. It is used in treating the physical symptoms seen in people affected by Parkinson's disease.
7. As a drug it is good for its action on the brain and the urinary bladder in disorders connected to these organs.
8. It is also used in homeopathic treatment and to relieve headaches caused by tension.

2.4 SUMMARY

Economic botany is the study of the relationship between people (individuals and cultures) and plants. This link between botany and Anthropology explores the ways humans use plants for food, shelter, medicines, textiles, and more. Plants are extremely important in the lives of people throughout the world. People depend upon plants to satisfy such basic human needs as food, clothing, shelter, and health care. Timber is a type of wood that has been processed into beams and planks, a stage in the process of wood production. It is commercially used in many purposes such as in making furniture's, construction work, frames, doors, windows, boats, railway sleepers etc. The beverages containing caffeine are used all over the world for their stimulating and refreshing qualities. Caffeine is an alkaloid, which has definite medicinal value and acts as a diuretic and nerve stimulant. Oils, oleoresins & extracts from plants are used in a wide variety of ways – in food, as medicine, in cosmetics & toiletry, as ingredients for industrial products, as fuel, and more. Essential oils are volatile, and are usually derived from the non-seed parts of the plants. Fiber yielding plants rank second only to food plants in their usefulness to human kind. The utilization of fibers is directly related to the advancement of civilization. They have enormous value in our daily life. The branch of medical science, which deals with the drugs plants, is known as Pharmacognosy. Most of the drugs are obtained from wild plants growing in all parts of the world, especially in tropical regions.

2.5 GLOSSARY

Ailments: an illness, typically a minor one.
Amphetamine: a racemic drug, that stimulates the central nervous system: used chiefly to lift the mood in depressive states and to control the appetite in cases of obesity.
Anti-androgenic: are a class of drugs which prevent androgens like testosterone and dihydrotestosterone (DHT) from mediating their biological effects in the body.
Antifungal: Antifungal medicines are used to treat fungal infections.
Antihypertensive: Anti-hypertensive are a class of drugs that are used to treat hypertension (high blood pressure).
Anti-inflammatory: Anti-inflammatory or anti-inflammatory refers to the property of a substance or treatment that reduces inflammation or swelling
Antispasmodic: (chiefly of a drug) used to relieve spasm of involuntary muscle.
Aphrodisiac: a food, drink, or other thing that stimulates sexual desire.
Arthritis: acute or chronic inflammation of a joint, often accompanied by pain and structural changes and having diverse causes, as infection, crystal deposition, or injury.
Asthma: a paroxysmal, often allergic disorder of respiration, characterized by bronchospasm, wheezing, and difficulty in expiration
Astringent: causing the contraction of skin cells and other body tissues.
Bronchitis: acute or chronic inflammation of the membrane lining of the bronchial tubes, caused by respiratory infection or exposure to bronchial irritants, as cigarette smoke.
Caffeine: a white, crystalline, bitter alkaloid, usually derived from coffee or tea: used in medicine chiefly as a nervous system stimulant.
Carminative: a drug causing expulsion of gas from the stomach or bowel.
Ciguatera: a tropical disease caused by ingesting a poison found in certain marine fishes.
Convulsion: contortion of the body caused by violent, involuntary muscular contractions of the extremities, trunk, and head.
Cordage: fiber and wire ropes, lines, hawsers, etc., taken as a whole, especially with reference to the rigging and other equipment of a vessel.
Cordial: a strong, sweetened, aromatic alcoholic liquor; liqueur.
Decoction: is a method of extraction by boiling herbal or plant material to dissolve the chemicals of the material, which may include stems, roots, bark and rhizomes.
Dermatophytosis: also known as ringworm, is a fungal infection of the skin.

Diabetes: is a group of metabolic disorders in which there are high blood sugar levels over a prolonged period.
Diuretic: increasing the volume of the urine excreted, as by a medicinal substance.
Dropsy: an old term for the swelling of soft tissues due to the accumulation of excess water.
Dysentery: is a type of gastroenteritis that results in diarrhea with blood.
Dyspepsia: is a pain or an uncomfortable feeling in the upper middle part of your stomach.
Epilepsy: a disorder of the nervous system, characterized either by mild, episodic loss of attention or sleepiness or by severe convulsions with loss of consciousness.
Expectorant: promoting the discharge of phlegm or other fluid from the respiratory tract.
Febrifuge: serving to dispel or reduce fever, as a medicine.
Flatulent colic: Severe abdominal pain caused by spasm, obstruction, or distension of any of the hollow viscera, such as the intestines.
Folk Medicine: health practices arising from superstition, cultural traditions, or empirical use of native remedies, especially food substances.
Gastrodynia: pain in the stomach; a stomach ache. Also called gastralgia.
Gout: an acute, recurrent disease characterized by painful inflammation of the joints, chiefly those in the feet and hands, and especially in the great toe, and by an excess of uric acid in the blood.
Heartwood: the hard central wood of the trunk of an exogenous tree; duramen.
Hepatoprotective: or antihepatotoxicity is the ability to prevent damage to the liver. This damage is known as hepatotoxicity.
Hernia: the protrusion of an organ or tissue through an opening in its surrounding walls, especially in the abdominal region.
Hypertension: elevation of the blood pressure, especially the diastolic pressure.
Hypoglycemic: an abnormally low level of glucose in the blood.
Illuminant: an illuminating agent or material.
Intermittent fever: any fever characterized by intervals of normal temperature.
Laxative: a medicine or agent for relieving constipation.
Leukemia: is cancer of the blood or bone marrow.
Lumbago: pain in the lower, or lumbar, region of the back or loins, especially chronic or recurring pain.
Mastitis: painful inflammation of the breast.
Mydriatic: is an agent that induces dilation of the pupil.
Nausea: sickness at the stomach, especially when accompanied by a loathing for food and an involuntary impulse to vomit.
Nephritis: inflammation of the kidneys.
Nodules: a tubercle, a small, rounded mass or lump.
Obesity: the condition of being very fat or overweight; corpulence.
Phlegm: the thick mucus secreted in the respiratory passages and discharged through the mouth, especially that occurring in the lungs and throat passages, as during a cold.
Piles: are swollen blood vessels in or around the anus and rectum. Piles are hemorrhoids that become inflamed.
Saponified: turn (fat or oil) into soap by reaction with an alkali.

Sapwood: the softer part of the wood between the inner bark and the heartwood.
Sautéed: cooked or browned in a pan containing a small quantity of butter, oil, or other fat.
Scurvy: a disease marked by swollen and bleeding gums, livid spots on the skin, prostration, etc., due to a diet lacking in vitamin C.
Spasm: a sudden involuntary muscular contraction or convulsive movement.
Stimulant: something that temporarily quickens some vital process or the functional activity of some organ or part.
Temperate: relating to or denoting a region or climate characterized by mild temperatures.
Tumor: a tumor is an abnormal growth of cells that serves no purpose.
Uremia: a condition resulting from the retention in the blood of constituents normally excreted in the urine.
Varnishes: resin dissolved in a liquid for applying on wood, metal, or other materials to form a hard, clear, shiny surface when dry.

2.6 SELF ASSESSMENT QUESTION

2.6.1 Short answer type question

1. The medicinally most important part of *Rauwolfia serpentina* is a:
Ans. Root

2. Castor oil is obtained from?
Ans. *Ricinus communis*

3. What are the botanical names of soya bean, ground nut and coconut?
Ans. Soya bean-*Glycine max*, Groundnut-*Arachis hypogaea*, Coconut-*Cocos nucifera*.

4. Name the fiber obtained from the husk of coconut.
Ans. Coir

5. Epidermal seed fibers are obtained from
Ans. Cotton

6. Reserpine, is a drug is extracted from
Ans. *Rauwolfia serpentina*

7. Which part of coconut produces coir?
Ans. Mesocarp

8. The alkaloid present in the tea leaves?
Ans. Caffeine and Theophylline, and Theobromine

2.6.2 Multiple choice questions

1. Which one of the following is a plant of great medicinal value?
(a) *Brassica oleraceae* (b) *Rauwolfia serpentine*
(c) *Coffea robusta* (d) *Cryptostegia grandiflora*

2. Fiber of great commercial importance derived from epidermis is:
(a) Flax (b) Hemp
(c) Coir (d) Cotton

3. Which one of the following plants is a rich variety of timber?
(a) *Cassia fistula* (b) *Dalbergia sissoo*
(c) *Acacia Arabica* (d) *Morus alba*

4. Soyabean oil is
(a) Drying oil (b) semi -drying oil
(c) Essential oil (d) None of all

5. Mustard oil is rich in
(a) Eurucic acid (b) Linoleic acid
(c) Palmatic acid (d) Stearic acid

6. Cotton fiber is
(a) Surface fiber (b) Hard fiber
(c) Bast fiber (d) Coir

7. Tea and coffee is a
(a) Distilled beverage (b) Alcohol beverage
(c) Non -alcohol beverage (d) Fermented beverage

8. Coffee is mainly grown in
(a) Karnataka (b) Andhra Pradesh
(c) Kerala (d) Orissa

9. Which of the following is cultivated for carbohydrates, protein and fats?
(a) *Arachis hypogaea* (b) *Cajanus cajan*
(c) *Ricinus communis* (d) *Cicer arietinum*

10. Which one of the following is the hardest wood?
(a) *Shorea robusta* (b) *Tectona grandis*
(c) *Cedrus deodara* (d) *Dalbergia sissoo*

11. Which one yield resin, timber and pulp?
(a) *Dalbergia* (b) *Pinus*

(c) *Eucalyptus* (d) *Quercus*

12. Jute is obtained from
(a) Primary xylem (b) Primary phloem
(c) Secondary xylem (d) Secondary phloem

13. Which one of the following is surface fiber?
(a) Coir (b) Sun hemp
(c) Cotton (d) All of these

2.6.3-Fill in the blanks

1. A drug which reduces high blood pressure is obtained from__________________
2. *Aconitum heterophyllum* belongs to the family__________________
3. A drug for the treatment of hypertension is obtained from_______________
4. Tea is a rich source of________________
5. Flax fiber are obtained from_____________________

2.6.2 Answers Key: 1-(b), 2-(d), 3-(b), 4-(b), 5-(a), 6-(a), 7-(c), 8-(a), 9-(a), 10-(a), 11-(b), 12-(d), 13-(c)

2.6.3 Answers Key: 1-*Rauwolfia serpentina*, 2-Ranunculaceae, 3-*Rauwolfia*, 4-Alkaloids, 5-*Linum usitatissimum*

2.7 REFERENCES

- Kochhar S.L., 1998, *Economic botany in the tropics*, Macmillan pub.
- Pandey B. P., 2012, *Economic Botany,* S. Chand publication.
- Nivedita Srivastava , 2014, *Medico Botany of Garhwal Himalayas*, Deep pub.
- Mangold J., Parkinson H., 2013, *Plant Identification Basics,* Department of Land Resources and Environmental Sciences.
- www.flowersofindia.net
- www.plants.usda.gov
- www.indianmedicinalplants.com
- www.biologydiscussion.com
- www.odishafdc.com
- www.dictionary.com

2.8 SUGGESTED READINGS

- Kochhar S. L., *Economic Botany: A Comprehensive Study*, 5th Edition, 2016.
- Maheshwari, P. & Singh, U. *Dictionary of Economic Plants in India*, I.C.A.R. New Delhi, 1965.

- Pearson, R.S. & Brown, H.P. *Commercial Timbers of India*. Central Pub. Branch, Calcutta, 2 Vols., 1932.
- Sammbamurty, *A Textbook of Modern Economic Botany*.
- Mangold J., Parkinson H., 2013, *Plant Identification Basics*, Department of Land Resources and Environmental Sciences.
- S. Sen., 2009, *Economic Botany*.
- John H. Wiersema, Blanca León, *World Economic Plants: A Standard Reference*, Second Edition.
- Dutta, P.K., I.C. Chopra and L.D. Kapoor. *Cultivation of Rauwolfia serpentina in India*. Economic Botany.
- Hill, A.F. Economic Botany; *A Textbook of Useful Plants and Plant Product*. McGraw-Hill Book Co., New York, 2nd Ed. 1952.
- Bailey, L.H. *Manual of cultivated plants*. The Macmillan Co., New York, 1949

2.9 TERMINAL QUESTIONS

1. What are the main characteristics of *Cedrus deodara?* Write about its role in Ayurvedic medicines.
2. What are the chief sources of Caffeine? Give an account on Beverages.
3. Write a short note on Oils. Discuss the role of Mustard and Groundnut in culinary cooking as well as in medicine.
4. Give an account on any two of the following:
a. Cotton b. Coir c. Jute
5. Give detailed account on Medicinal plants. Write about the medicinal role of *Rauwolfia serpentina*.
6. Write an essay note on, medicinal uses of the plant *Atropa belladonna*.
7. What is the chief constituent of *Cinchona* plant? Describe the economical importance of it.