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PLANT RESOURCE UTILIZATION AND CONSERVATION

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CHAPTER 1

PLANT BIODIVERSITY

LEARNING OBJECTIVES

- Concept
- Sustainable Development
- Origins of Agriculture
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Concept

Biodiversity is related with different species found in the nature. Rogen first of all gave this word in 1986. Although biodiversity is controlled by different methods, but biotechnology has an important contribution in biodiversity conservation. It is hoped that in the 21st century, its conservation will totally be dependent on biotechnology. The whole world can be divided into four zones on the basis of biodiversity and biotechnology:

1. Countries poor in both biotechnology and biodiversity, such as, Arabian countries.
2. Countries poor in biodiversity, but rich in biotechnology, such as, UK, USA, France.

3. Countries rich in biodiversity, but poor in biotechnology, such as, India, Nepal, Bhutan, Pakistan.

4. Countries rich in biodiversity and rich in biotechnology. It includes no country.

Hence relations have been established among such countries, which come in second and third zones. Some countries can transfer biotechnology to them and others can transfer biodiversity to them. If biodiversity is determined in a specific area, then it is called as point or alpha biodiversity, but if biodiversity is observed in the whole space, then it is called as beta biodiversity.

Causes for Biodiversity Conservation

1. Interdependence- In ecosystem, all the species are dependent on one another. Hence if one species gets destroyed, then 40-45 species get affected.

2. Ecology- The specific characters of any region are controlled by the species found there. Hence if species gets destroyed, then ecosystem gets unbalanced.

3. Economy- In several countries, economy is based on the forest products. Hence on the destruction of species, economy also gets affected.

4. Biology- Different types of genes are found in different species. These genes are the main source of variations. Hence on the destruction of species, genes also get affected.

Current Level of Biodiversity

It has been observed that in the whole space, approximately 10^8 species are found, among which 10 species are extincting every year. At the global level, every year 1.8% forests are going to extinct. In the forests, 2 million species have been observed, among which every year about 4000 species are getting destroyed due to deforestation. The current status of biodiversity is as follows:

i) Diversity in terrestrial system is more than that in the marine system.

ii) Arthropoda is having much of the biodiversity.

iii) Among the mammals, rodents are having much of the biodiversity.

iv) Among monocots, orchids are having much of the biodiversity.

v) In tropical areas, there is much of the biodiversity.

Types of Biodiversity Conservation

a. Habitat Conservation- When the whole habitat is conserved, then it is called as habitat conservation. It is done in the form of national parks, sanctuaries and biosphere reserves.

b. Specific Conservation- This conservation is done for a specific species, such as, tiger has been protected by 'Tiger Project'. Similarly, Hingul Project, Crocodile Project and Elephant Project have been started.

c. In-situ Conservation- When conservation of species is done in its natural habitat, then it is called as in situ conservation, which is done by national parks, sanctuaries and biosphere reserves. In India, this policy has been started since 1952. In India total 84 national parks and 462 sanctuaries have been established. In M.P., 11 national parks and 31 sanctuaries are there.

Along with it, projects have also been prepared for specific conservation. In 1972, 18 tiger projects have been launched. Along with these, Crocodile Project, Hangul Project, Musk Deer Project, Waste land Project and Mangrove Projects have been launched. Elephant Project was started in 1991 in Periyar. Four coral and coral reef projects have also been started, these are Gulf of Mannnar, Gulf of Kutchh, Andaman and Nicobar islands and Lakshadweep area.

c. Ex-situ Conservation-When conservation is done out of the natural habitat, then it is called as ex-situ conservation. For it, a central authority has been established. In India, animals are conserved in zoos. Conservation of germplasm of plants is done in National Beureau of Plant Genetic Resources (NBPGR), New Delhi. Later on, in 1986, Department of Biotechnology (DBT) has been established. Ex-situ conservation is done with the help of following techniques:

Artificial Seed

These are also called as synthetic seeds. It is the best method for germplasm conservation. In this process, somatic embryo is capsulated in suitable matrix, like-sodium alginte. Along with these, mycorrhiza, insecticide, fungicide etc. are also mixed. In India, P.S. Rao in BARC has started this process for Sandalwood and Mulberry. This system has been called as low-high volume system. For it, two types of artificial seeds have been prepared. Radenberg (1986) mixed somatic embryo with sodium alginate and had flown it in the calcium chloride solution, where beads of calcium alginate were obtained. These are called as hydrated artificial seeds. 29-55% embryos are capsulated in hydrogel , which form seedlings *in vitro*. Kim and Janick, I 1989, added mixed somatic embryos in 5% polyethylene oxide solution, which is a water-soluble resin. It dries up and forms polyembryonic desiccated wafer; chilling in 12% sucrose solution and at high inoculum density does hardening of embryo. These are called as desiccated artificial seeds, but these seeds are having much more chances of contamination. Artificial seeds are having the following advantages:

I) These seeds can be stored without the loss of viability up to one year.

II) These can be easily handled and can be given in the form of units.

III) These can be grown directly in the soil. Hence, these do not need hardening in green house, ex. Bamboos.

Cryopreservation

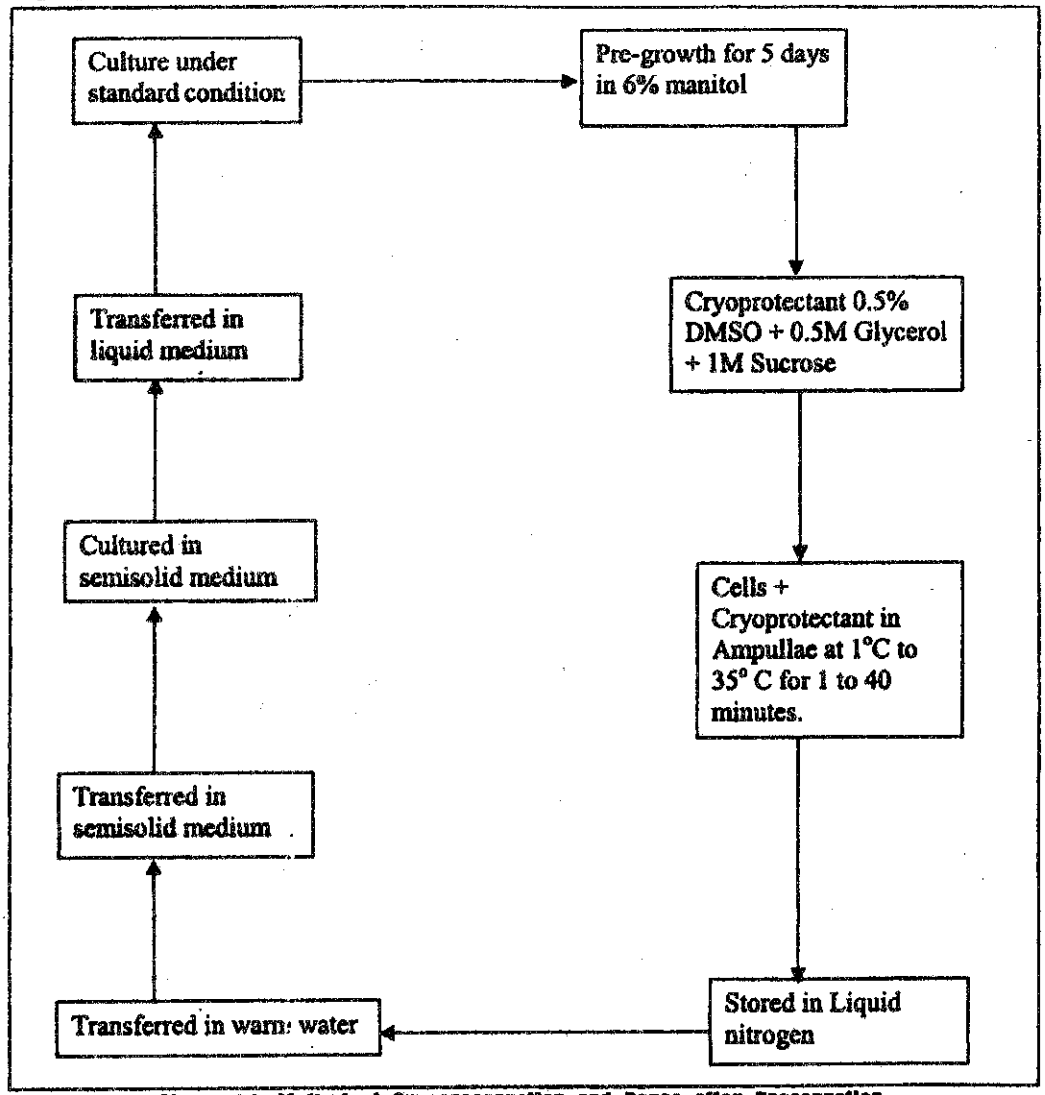

Figure 1.1: Method of Cryopreservation and Banks after Preservation

Many National and International institutions are related with cryopreservation, as NBPGR, IPGRI. In this process, germplasm is preserved at very much low temperature. At this temperature, viability does not get reduced. This germplasm can be seed, bud, protoplast, cells, tissues etc. Liquid nitrogen is also used in cryopreservation. Freezing is done in definite steps. First of all, tissue is obtained in a standard condition. It is grown in 6% mannitol medium, and then cryoprotectants are used in it, which are 0.5% DMSO, 0.5 M glycerol and 1 M sucrose. This solution is then transferred into a test-tube and now it is freezed for one minute at 10°C. Then, temperature is reduced upto –35°C and it is conserved in liquid nitrogen. Whenever it is required, then test-tube is transferred into hot water and then to the semi-solid medium. Later on, tissue is transferred onto the liquid medium. This process has been used in cryopreservation of different plant parts.

Gene Banks

Ex-situ conservation is done along with the establishment of gene bank. It includes genetic resource centres, zoos, botanical gardens, culture collections etc. It includes in-situ conservation also because national parks and sanctuaries are also gene banks. Gene banks are important because these provide genetic resources for crop improvement and forestation programs. In International Agricultural Research centres, six lakh types of seeds have been aggregated. In 1974, International Board for Plant Genetic Resources has been established (IBPGR), which has been renamed as IPGRI in 1993. G-15 countries have established a network of gene bank, in which aromatic and medicinal plants are conserved. In USA, seed storage is done in National Seed storage Laboratory, Colorado. In India, national gene banks are of three types:

i) Seed repository storage at –20°C

ii) Cryobank storage at –196°C

iii) Tissue culture repository storage at 10-25°C

For conservation, DBT, NFPTCR (National Facility for Plant Tissue Culture Repository) have been established, where *in vitro* conservation technology is used.

For crop and forest conservation, International Center for Research on Agro Forestry (ICRAF) has been established. Some important institutions, which are related with conservation, are as follows:

1. NSGC – National Small Grain Collection
2. NERPIS – North East Regional Plant Introduction Station
3. WRPIS – West Regional Plant Introduction Station
4. NCRPIS – North Central Regional Plant Introduction Station
5. IRPI – Inter Regional Potato Introduction Project
6. ICARDA – International Centre for Agricultural Research in Dry Areas.
7. WARDA – West African Rice Development Association

Legal Steps for Conservation

According to act 48A, 33% part of area is covered by vegetation. According to act 51, wild life must be conserved and exploitation must be prevented. In 1973, National Wildlife Plan has been presented, in 1988, National Forest Policy has been proposed and in 1992, National Conservation Policy has been presented. Different legal acts have been given for wildlife protection, as Indian Forest Act (1927), Wildlife Protection Act (1972), Forest Conservation Act (1980), Environment Protection Act (1986).

Biodiversity Status In India

The Zoological Survey of India, the Botanical Survey of India and the Forest Survey of India have been studying and documenting the plant and animal diversity of country. Of the estimated 45,000 plant species, about 15,000 species of flowering plants have been described. Estimates of other plant taxa include 5,000 algae; 1,600 lichens; 20,000–2,700 bryophytes and 600 pteridophytes. There are about 75,000 species of animals including 50,000 insects; 4,000 molluscs; 2,000 fishes; 140 amphibians; 420 reptiles; 1200 birds and 340 mammals and other invertebrates.

Utilization and Concerns

Biodiversity is utilized in different ways. Some important ways are following:

1. Biodiversity hot spots are major gene banks.
2. It gives us genes for disease resistance.
3. It gives genes for stress resistance.
4. It gives different types of medicines.
5. It shows diversified types of food.
6. It gives us different types of pigments and other industrial products.
7. It provides the diversified forage and fodders.
8. It shows aesthetic values.
9. It is related with ethno-botanical importance.
10. The economy of many countries is based on biodiversity, specially the developing countries.

It is the reason that the major threat is continue destruction of natural habitats and hence disappearance of biodiversity. Major threats for biodiversity destructions are following:

1. Destruction of natural habitats for colonization and agriculture.
2. Destruction of plants due to dams, railway lines and roads.
3. Over exploitation of natural habitats.
4. Over population and hence increasing demand of fuel and timber- wood.
5. Increasing pollution.
6. Seasonal variation.
7. Drought and flood.
8. Uneven rainfall.

Beyond these many other causes are also responsible like acid rain, ozonolysis, global warming etc. It is estimated that daily one specie is disappearing from nature. Main concern is, we are not aware to many unexposed areas.

Sustainable Development

Basic concepts

Brundlendt proposed concept of sustainable development in 1987. He proposed better solutions for ecological management. According to him, direction of development should be in such a way that without disturbing the nature or ecology, development must be continued and human beings must get better life. The better direction of development is that in which we can transfer the natural assets to the next generation in the similar stage as we got it from our past generation. Such a development is known as Sustainable Development. Thus, Sustainable Development is "meeting the needs of today without reducing the quality of life for future generations."

It includes scientists, environmentalists, politicians and society, because nature cannot be maintained by the effort of a single person. Moreover, without sacrificing with our needs, we can conserve the nature. It is based on the following points:

1. **Development-** It is of two types: quantitative or qualitative. Quantitative development indicates expansion irregularly, while qualitative development is based on natural principles, which favour the nature. Regeneration capacity of the earth is so high but we are using less and destroying more, like we are having huge amount of water, but all of it is not available to man which is due to lack of sustainability.
2. **Needs-** It is necessary to identify the basic needs, because a few rich persons are destroying the nature for managing their living standard and poor people are the sufferers. It means that our interpretation for the needs is wrong. That's why proper redistribution of resources among the people is necessary, because inequality in the society leads to irregular development. So it is a major barrier for sustainable development.
3. **Future Generations-** It is our moral duty to provide better environment to the future generations. It doesn't mean that we cannot use the resources. Actually if the use of resources is our right, then the regeneration of resources is our duty. So if we are using our right, we must fulfill our duty.

Goals of Sustainable Development

Five major goals have been proposed for sustainable development:

i) **Resource Conservation-** Conservation of natural resources shows that if we are using the resources, then we must maintain the purity of the resources

ii) **Built Development-** Direction of the development must be constructive. It means development should be parallel to the nature, which will not disturb the nature.

iii) **Environmental Quality-** Such developments must be avoided which degrade or pollute the environment. Only such developments should be adopted that initiate regeneration of ecosystem.

iv) **Social Equality-** Such developments should be avoided which will promote the difference among rich and poor people, because sustainable development means to induce eq lity in the society.

v) **Political Participation-** It is well known that the decision authorities are politicians. So, if environmentalists or society provides any recommendation, then we must involve the politicians, otherwise the decisions will be useless.

Assumptions and Trends

The sustainable development is based on strategies, policies and methods. So we must assume the needs of future and policies should be decided according to the needs. To fulfil these needs, particular methods must be adopted. The imagination and forecasting are also important. If the present trends are constructive, then we must follow it, otherwise it should be changed.

Present Conflicts and Future Priorities

Environment degradation is important for rich persons as well as for poor persons. But if the poor are not getting the food, space and energy source, then they will destroy the nature for getting these things because their priority is to get the food. So the present confliction is that rich community is trying to maintain the nature because they are having the other sources for fulfilling the needs, but poor people are destroying the nature, as they are having no alternative. It is the fact that survival is the priority. So without fulfilling the needs of poor, we cannot achieve the target of sustainable development. That's why our future priority must be to enhance the living standard of poor.

General Principles for Sustainable Development

Ten general principles have been proposed for maintaining sustainable development:

1. **Fundamental Change in Attitude-** Sustainable development is mainly based on essential needs, but many times non-essential facilities are assumed as essential needs. So we must change the attitude. For this purpose, following means can be adopted:
   a) Environmental census and projections
   b) Monitoring targets

c) An integrated education and publicity policy

d) Publishing and rewarding major achievements.

2. **Facilitating Innovation and Replicating best Practices-** At present time, many trends are quite good which protect the nature. But these practices are not common. So the expansion of such practices will be beneficial for the environment. For this purpose, supportive programs must be launched, like to provide the financial aid for energy-saving technologies, penalties for damaging the environment, funding for innovative research.

3. **Sustainability Indices-** The minimum criteria should be fixed for sustainable development and target should be set for improving the environment. Such agencies should be involved which can provide positive decisions in favour of the environment.

4. **Initiation Level-** Scope of sustainable development is maximized when initiation takes place at all levels. These levels and techniques are as follows:

   a) Community involvement

   b) Decentralization

   c) Positive incentives

   d) Removal of barriers

   e) Creation of policy and administrative framework

5. **Redefining Growth in Terms of Quality of Life-** It is clear that irregular expansion is known as quantitative growth, but we need qualitative growth which favours the nature as well as living standard.

6. **Redefining Costs and Profitability-** Generally in the costs of products, the cost of environment is not included. So the cost of pollution control should be included, then the profitability is calculated.

7. **Long-term Planning-** The nature is degraded much due to short-term planning. So, the long-term planning should be carried out which gives time to natural regeneration.

8. **Continuity of Policy and Framework for Decision Making-** If once the policy is administered, then it must be continued which will indicate the positive growth. Actually many decisions are changed due to political pressures. So if once the decisions are taken on the basis of framework, then it should not be changed.

9. **Environmental Standard, Capacity Limits and Impact Assessment-** For the standard limits, national bodies should take the decisions and time to time, decisions should be revised.

10. **Finance for Long-term Planning-** Finance is the backbone for any technology. So, if once the decisions are implemented, finance should not be the barrier. Hence, before the implementation, finance should be available.

Origins of Agriculture

Agriculture is man's oldest occupation. He discovered it from the dispersal of seeds. When the seeds germinated and produced new plants, then man learnt this process. It is imagined that agriculture has independently originated in following areas

i) Lower slope of Zagorase mountain.

ii) Fertile crescent of Tigris valley

iii) Euphrates valley in northern Iraq (old world)

iv) Tehucan valley of Mexico (new world)

Earliest evidences show that agriculture was originated about 7000 B.C. and the ancestors of cultivated plants were present in the nature. Although now-a days, many plants have changed in such a way that their ancestors cannot be traced.

Domestication of Plants

Although for a long time, domesticated plants were not studied. First time, in true sense, Theophrastus, who is called as **'Father of Botany'**, carried out study. Beyond it, Dioscorides, Pleny, Galen also studied cultivated plants. The de-materia medica was the important ancient book written by Dioscorides. The works done by Aristotle and Theophrastus were considered as complete work, which had been done in 14th century. One old belief is that the cultivated plants are God-gift to man and the process of cultivation was itself improved by heredity. Although in 1807, Humboldt told that we know nothing of the original sources of useful plants. Their origin is an impenetrable secret. Darwin considered that cultivated plants originated from wild plants. Mendel considered that cultivated plants have been originated due to hybridization and natural selection.

de'Condolle studied 247 species of cultivated plants, and tried to solve the mystery of origin. He proposed regions of domestication and history of useful plants. He used many evidences taken from Theophrastus, Dioscorides, traveller's accounts, Chinese writing, archeological and ethnological findings and phytological evidences. He classified the economic plants into six classes as follows:

Plants of Old World Origin

These plants have been cultivated before 4,000 years and possibly longer. This include-

almond	fig	peach
apple	flax	pear
apricot	grape	rice
banana	hemp	sorghum
barley	mango	soyabean

cabbage	millet	tea
date	olive	watermelon
eggplant	onion	wheat

Plants cultivated for at least 2000 years and probably longer. This include-

alfalfa	oats	radish
asparagus	breadfruit	cherry
beet	carrot	chestnut
cotton	celery	citrus fruits
lettuce	pea	rye
mustard	pepper	sugarcane
plum	walnut	poppy

Plants cultivated for less than 2000 years. These include-

artichoke	muskmelon	rhubarb
buckwheat	okra	strawberry
coffee	parsley	currant
parsnip	gooseberry	raspberry

Plants of new world origin-

- Plants cultivated certainly over 2000 years and probably more than 4000 years. These are cocoa, maize, sweet potato, kidney bean, mate, and tobacco.
- Plants cultivated before the time of Columbus, but those antiquity is known; avocado, cotton (some species), groundnut, guava, pineapple, potato, pumpkin, pepper (red), squash, tomato, vanilla.
- Plants cultivated since the time of Columbus;
- Allspice, blackberry, black walnut, blue berry, cinchona, dewberry, gooseberry, pecan, plum, rubber, strawberry.

De Condolle's deductions concerning the domestication of cultivated plants are still largely accepted. He pointed out that cultivated plants originated at some time in the remote past from wild ancestors in rather restricted areas of the world with no communication what so ever with each other. These are- China, southwest Asia including Egypt and inter tropical America. He believed that each of the various crops commonly had a single region of origin.

World Centres of Primary Diversity of Domesticated Plants

The area where first ancestor of domesticated plants was occurred is known as primary diversity centre. First time, Vavilov did the important work for primary centres. He was the expert of crop geography and geneticists. His conclusions were based on morphology, anatomy, cytology, genetics, disease distribution and disease reactions. He observed that distribution of species was not uniform. In a limited area, wide range of genetic variability has been observed. About 50% diversity was seen in Ethiopia and South America. Vavilov called such regions as agro ecological groups, while Harlan called it microcentres.

Although different scientists proposed different number of centres, Vavilov proposed 11 centres, while Darlington proposed 16 centres and Zhukovsky proposed 12 mega gene centres.

Vaviloian Primary Centres

The gene centres are identified through dominant genes, which are replaced by recessive alleles. In the starting, Vavilov proposed six centres, later increased up to 11 centres, in which 8 are major centres and 3 are minor centres.

1. **Chinese Centre:** It is easiest and earliest largest centre. It includes central and western China. It is having 136 endemic crops, like- millet, soyabean, bamboo, brinjal, cherry, citrus, sugarcane, cinnamon and tea.
2. **Indian Centre:**
   - **Main Centre** includes Assam and Burma. 117 plants are endemic, like- rice, sugarcane, mango, jute, coconut, black pepper.
   - **Indomalayan Centre** includes indo-china and Malaya regions. 55 plants are endemic, like- banana, coconut, sugarcane, clove, manila hemp.
3. **Central Asiatic Centre:** It includes north-west India, Afghanistan, Russia and west China. 43 plants are endemic. Common plants are wheat, pea, beans, lentil, hemp, cotton, carrot, garlic, spinach, apricot, almond, apple and pear.
4. **Near Eastern Centre:** It includes Asia minor, Iran and highlands of Turkmanistan. 85 species are endemic. 9 species of wheat and rice are indigenous, like- cherry, pomegranate, walnut, almond, fig etc.
5. **Mediterranean Centre:** It includes the borders of the Mediterranean sea. 84 plants are known to have originated and these include olives and many cultivated vegetables (garden beet, cabbage, turnips, asparagus); forage plants (Egyptian clover, white clover, crimson clover); oil-yielding plants (rape, black mustard); wheat (durum and emmer) and ethereal oil and spice plants (thyme, caraway, sage, hops).

6. **Abyssinian Centre:** It includes Abyssinia (Ethiopia now), Eritrea and parts of Somalia. 38 species are native to this region. Wheat and Barley especially rich in diversity and others include sesame, castor bean, coffee and okra.
7. **South Mexican and Central American Centre:** It includes the southern parts of Mexico, Guetemala, Honduras and Costa Rica. Endemic plants are extremely varied and include maize, bean, squash, sweet potato, red pepper, upland cotton, sisal, papaya, guava, cocoa and tobacco.
8. **South American Centre:**
   - **The Peruvia-Ecuadorean-Bolivian Centre:** It consists of mainly of high mountains areas represents the centre of pre-inca civilization. Plants native to the Puna and Sierra uplands are also included. This centre is known to be the original home of any potato species, tomato, lima bean, pumpkins, red pepper, cocoa, Egyptian cotton, quinine tree and tobacco.
   - **The Chiloe Centre:** It is an island near the coast of southern Chile, is thought to be the region of origin of the common potato.
   - **The Brazilian-paraguayan Centre:** It is believed to be the region of origin of groundnut, cassava, pineapple, rubber tree and cashew nut.

Vavilov proposed the primary and secondary gene centres where native wild plants started domestication and which are having the dominant genes are known as primary centres, but as cultivated plant, these are migrated to other gene centres are known as secondary centres. In these gene centres, cultivated plants are transferred from different places. Recessive characters characterize these. Abssynian centre is rich in wheat, barley, pea and flax, which are having no wild relative in this area, but found in the Middle East Ethiopia. Many plants have multiple origin centres. Similarly, the secondary crops originated from primary crops.

Secondary Centres or Gene Centres

Zhukovsky proposed another concept and he used the term- 'mega gene centre'. These centres cover large area except Canada, Brazil, Siberia and Argentina. He proposed 12 mega gene centres, which are following-

1. China
2. Indochina
3. Australia- New Zealand
4. Indian subcontinent
5. Central Asia
6. West Asia
7. Africa
8. Europe-Siberia

9. Central America
10. Bolivia-Peru-Chile
11. North America
12. Mediterranean coastal and adjacent regions

Harlan proposed 'Diffused origin' concept. According to Harlan, crops were domesticated at different locations at different time. So we cannot pinpoint any single centre of origin. Thus, these show diffused origin, like- *Helianthus annus* shows large gene reservoir. Harlan criticized the centre concept. He developed idea of centres and non-centres. According to him, three independent centres and non-centres. According to him, three independent systems of centres and non-centres can be proposed, which are following:

Centre		Non-centre	
A1	Near East	A2	African
B1	North Chinese	B2	South Eastern and South Pacific
C1	Central America or Mesoamerican	C2	South American

Plant Introductions

Introduction of a new variety is the quickest way to affect crop movement with a minimum of effort and cost. According to Allard (1960), plant introduction is " the acquisition of superior varieties by importing them from other areas." Frankel (1957) puts it as " transposition of a genetic entity from an environment to which it is attended to one in which it is untried." White (1958) suggested that plant introduction might be taken to mean the introduction of wild plants into cultivation. Bennet proposed that the introduction of wild plants into cultivation and the successful transfer of cultivars, with their genotypes unaltered, to new environments would together be designated as primary plant introduction work and the rest as secondary.

1. **Primary Introduction:** The direct introduction of introduced plants into cultivation to new environments, e.g., wheat (Ridley), oat (Kent), tomato.
2. **Secondary Introduction:** It is the systematic and methodical collection of wild plants to use as donors of useful characters by selection and hybridization, e.g., Mexican dwarf wheat, Taiwan rice, etc.

Purpose of Plant Introduction:

1. To secure, for possible general use, any outstanding local varieties being grown by the farmers in any other part of the country.
2. To obtain from the other countries varieties adapted to soil and climate conditions similar to those of the breeder's own country.
3. To obtain either or local or foreign varieties having particular characters needed in the breeder's hybridization program.

Plant Introduction Work In India

In India, some pulses (*Dolichos, Vigna, Cajanus*), cotton (*Gossypium arboreum*), jute (*Cochorus olitorium*), pepper (*Piper nigrum*), mango (*Mangifera indica*) etc. represent the introduction of wild plants into cultivation. Portuguese introduced maize, groundnut, potato, chillies, tobacco and pineapple. Britishers introduced litchi.

i) **Recent Primary Introduction:** Some of the exotics got acclimatized in certain regions. The Australian wheat 'Ridley', the Australian oat 'Kent', the U.S. peas 'Bonneville' and 'Early Badger' have spread all over the northern plains. Similarly good introduction of vegetable cowpea, cauliflower, French bean, onion, lettuce, watermelon, etc. have gone on the approved list of varieties for distribution.

ii) **Secondary Introduction:** Some exotic accessions of wheat, maize, sorghum, American cotton, linseed and many other crops have been and are being used in improving upon their indigenous counterparts by employing selection and hybridization techniques.

Value of Introduction

In addition to its value as a new variety, the introduced variety may serve as a source of new characters for hybridization program. The continuity of introductions from year to year enables the breeder to replenish his store of germplasm every year.

Review Question

1. What are the causes for Biodiversity conservation ?
2. What is the difference between in-situ and ex-situ conservation?
3. What do you understand by the term Gene-bank?
4. What is the basic concept of sustainable development?

CHAPTER 2

ORIGIN, EVOLUTION, BOTANY, CULTIVATION AND USES

LEARNING OBJECTIVES

- Food, Forage and Fodder Crops
- Fiber Crops
- Medicinal and Aromatic Plants
- Vegetable Oil-yielding Crops
- Important Fire-wood and Timber-yielding Plants and Non-wood Forest Products

Food, Forage and Fodder Crops

Food Crops

In the category of food crops, different types of crops are categorized, like- cereal crops, pulse crops, vegetables. These are important sources of carbohydrates, proteins, fats, minerals and vitamins.

Cereal Crops

It includes wheat, rice, jwar, bajra, maize, barley and millets, but the large percentage is of wheat, rice and maize. Some important cereal crops are following:

1. Triticum aestivum

Common name- Wheat

Family- Graminae

Origin centre- Central Asia (hexaploid), Asia minor (diploid) and Ethiopia (tetraploid)

Evolution

The wheat crop is generally diploid, tetraploid and hexaploid. The number of chromosomes are 7, 14 and 21. Tetraploids and hexaploids have been developed from diploid wheat. It is the result of allopolyploidy. The evolution of tetraploid and hexaploid species is as follows:

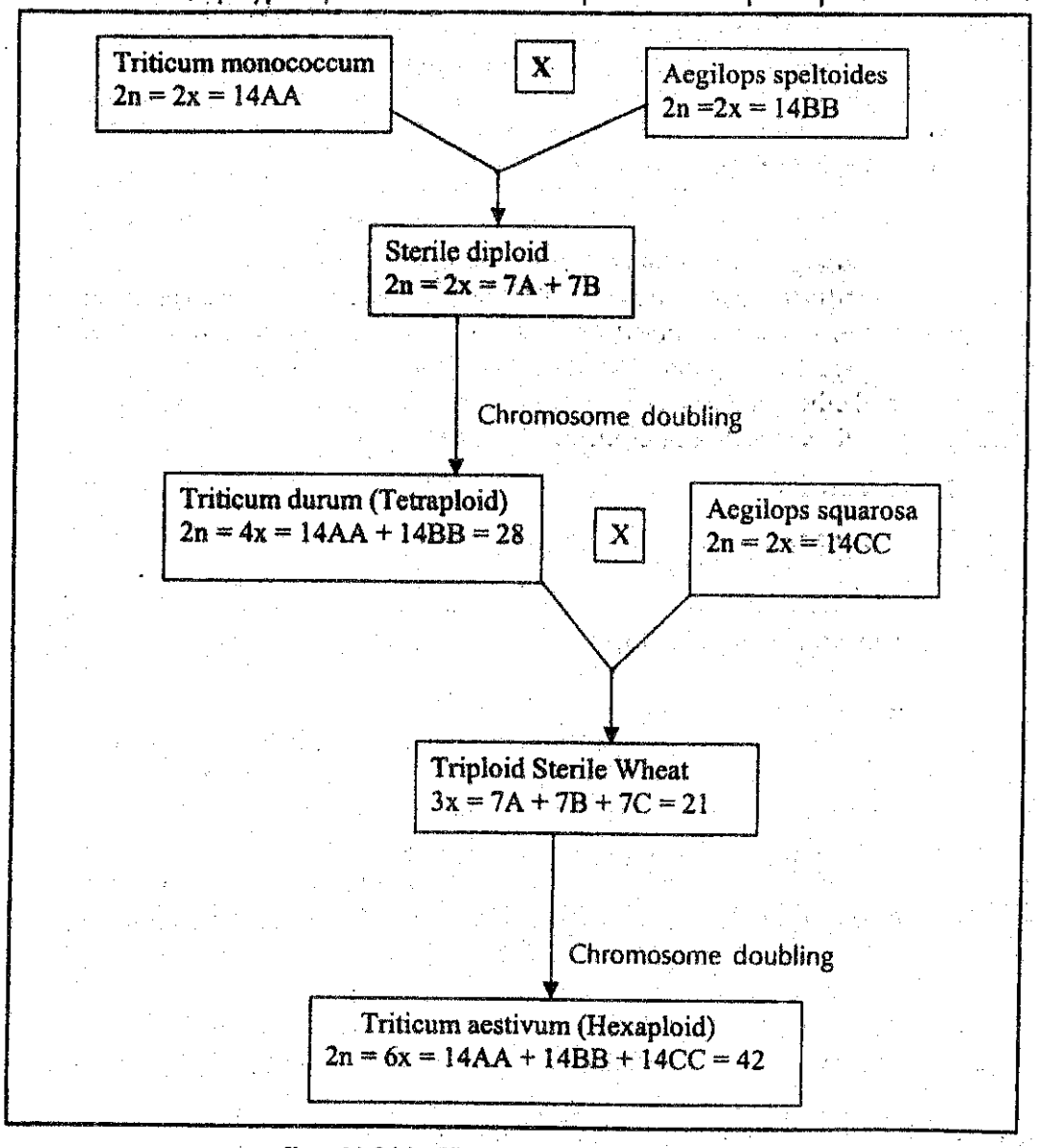

Figure 2.1: Origin of Hexaploid Wheat Triticum Aestivum

Botany

Stem is erect, cylindrical, nodes and internodes are present. Internodes are hollow. Adventitious root system and coronal roots are present. Leaf is made up of lamina, leaf sheath, ligules and auricles. Inflorescence is terminal spikelet; rachis is zig-zag, seeds are dry; grains are one-seeded caryopsis type; grain is made up of grain coat, endosperm and embryo.

Cultivation

It is widely cultivated plant, mainly cultivated in warm temperate region. Rainfall is 30-90 cm. It is grown in dry climate, and then becomes hard; it is glutein rich; protein is 11-15%. It is grown in silt and clay loams. In India, it is grown in Indo-Gangetic plain, Haryana, Punjab, Rajasthan, Maharashtra, Madhya Pradesh, Andhra Pradesh. It is sown in September or October and the crop is obtained during March-April. It needs two irrigations during crop season: during 4-6 weeks after sowing and during bloom stage.

Uses

Wheat and wheat products contribute greatly to the world's food supply and constitute an important source of carbohydrates in human diet. It has baking qualities. Wheat is consumed principally in the form of leavened bread, chapattis and in culinary preparations such as tandoori roti, nan, paratha and poori. The wheat flour is used in making cakes, biscuits, pastries crackers and other products. Durum wheat is especially used for the manufacture of macaroni, spaghetti, vermicelli and products as noodles.

2. **Oryza Sativa**

Common name- Rice

Family- Poaceae

Origin centre: India or Indochina.

Botany

It is semi aquatic in habitat. It is free-tillering, annual grass, stem is cylindrical and jointed; 50-150 cm. tall; internodes are short. Root system is shallow. Leaf is made up of leaf sheath, leaf blade and auricles. Ligule is colourless. Inflorescence is loose, terminal panicle; spikelets are single. Rice grain is caryopsis. Grains are differentiated into epicarp, mesocarp, cross cells, tube cells and spermoderm. Endosperm is made up of single aleurone layer. Aleurone layer is having oils, proteins, mineral salts and vitamins. Pericarp, nucellus, aleurone layer and embryo are known as bran.

Cultivation

Rice is sown in the wetlands. It needs higher amount of water. It is grown from sea level to 3,000 m height. During the growing season, temperature must be high, abundant source of water must be available, soil should prevent the water loss. For the different varieties, different growing seasons, soil conditions, temperature, rainfall and altitudes are needed. It

is the crop of swampy soils. Rainfall should be from 180-240 cm. Temperature should be from 21-35 °C. Generally, manure or compost fertilizers are applied.

Uses

It forms the main basis of diet. 90% rice is eaten in the form of various cooked preparations. The great bulk is plain boiled rice, often consumed with cooked pulses, curd, vegetables, fish or meat. The other Indian rice preparations are kheer, firni and pulao. In South India, it is used in fermented preparations such as dosa, idli and uppma. It is also used as parched rice and parched paddy. Rice flour is used in confectionary, ice-creams, puddings and pastries. Rice starch has laundering values and has wide industrial potential in the cosmetic industry, as a thickener in calico printing, in the finishing of textiles and for making dextrins, glucose and Adhesives. Alcoholic drinks such as 'Sake' and 'Wang-tsin' are also made from it. Rice husk is used as animal fodder. Rice bran oil is used for edible purposes. Rice straw is used for making a very fine type of paper.

3. Zea Mays

Common name- Maize

Family- Poaceae

Origin centre: Southern Mexico

Evolution

Cultivated maize is originated from wild form of pod corn.

Botany

It is erect, fast growing, single stemmed annual grass. Root is seminal, coronal or aerial. Plant is monoecious. Male inflorescence is known as tassel and female is known as ear. Male inflorescence is compact panicle. Corn is a caryopsis. Pericarp is fused with seed coat. Seed dispersal mechanism is not possible. It is having 82% endosperm and 12% embryo, 5% hull and 1% tip cap. In the aleurone layer, protein is present.

Cultivation

It is rich-land crop and shows wild distribution. It needs fertile, well-drained loam soil, distributed rainfall. Growth season is 110-130 days. It needs higher level of organic content and nutrient. Percentage moisture should be high. It needs long hot growing season. It requires a lot of N, P, K, Ca. It is sown just with the beginning of monsoon.

Maize must be stored in well-ventilated bins, so that excess moisture evaporates and the grains must subsequently be fumigated with chemicals to protect them against rodents and other pests.

Uses

From tassel to root, the maize plant is valuable. The stalk, leaves, silk, cob and kernels all have a commercial value. Maize is used mainly as a staple human food, a feed for livestock and as a raw material for many industrial products.

4. Hordeum Vulgare

Common name- Barley

Family- Poaceae

Origin centre: Ethiopia

Botany

It is annual plant. Height is about 60-120 cm. It is having three one-flowered inflorescence at each node. Head is having six rows of spikelet, grain is having lema and pelia.

Cultivation

As wheat

Uses

Barley is used in malting for brewing beer and other liquors like whisky, brandy etc. It has high percentage of starch. Pearled barley flour is used in the preparation of soups, baby gruels and other foods. The 'barley water' is used for the treatment of the inflammation of the membranes of the chest and feverish disorders. It is used as a human food in some parts of India. Young plants provide nutritious green fodder for cattle.

5. Avena Sativa

Common name- Oat

Family- Poaceae

Origin centre- Asia minor

Botany

Its foliage is blue tint, auricles absent in the lamina, leaf sheath covers internodes. Inflorescence is branched panicle. Long pedicel is present in spikelet. Each spikelet is having three flowers. Second flower is generally sterile. Florets are self-pollinated; grains are caryopsis. Grains are having hairy pericarp and double-layered aleurone and starchy endosperm.

Cultivation

It is the crop of humid temperate region. It is adapted to different agro climatic conditions. It is planted in the spring and winter season.

Uses

It is the most nutritious cereal, 3-4% is used as human food, protein is 13.8%, fat 4.3%, vitamin B_1 and mineral, iron and phosphorous are present. It is used as fodder also, it is the popular breakfast also. It is the popular breakfast food in Scotland and England. Its straw is used as fodder. Its hull is also used as fuel and packaging material.

Pulses

Almost all the pulse crops are protein rich. These provide many essential amino acids. Almost all the pulse crop belongs to leguminosae family. Actually, these belong to its subfamily–Papillionatae, their seeds are minerals and vitamin-B rich. Important legume crops are as follows:

1. Cajanus Cajan

Common name- Pigeon pea/Arhar/ Tuar

Family- Leguminosae

Origin centre: Africa

Botany

It is a woody, perennial shrub. Its length is 1-4 meter and grown in the form of annual crop. Leaves are trifoliate. Flowers are yellow or purple. Pods are 5-10 cm. long and seeds have colour varied from black to yellow red or brown.

Cultivation

It is deep-rooted, drought resistant crop grown in semiarid zone. It can also grow in area having less than 60 mm. It matures in 6-10 months, and by extracting the seeds from pods, pulses are made.

Uses

In South India, it is the important source of nutrition. It contains protein, vitamin B, calcium, phosphorous. Green pods are used as vegetables and broken seeds are used as fodder for dairy cattle. Green leaves are used as fodder and manure. It has 22.3% proteins, 1.7% fats, 57.2% carbohydrates, 3.6% minerals.

2. Cicer Arietinum

Common name- Chick pea (gram)

Family- Leguminosae

Origin centre: Southwest Asia

It is a major pulse crop of Europe. Chickpea is found in allover the world. Its largest producer is India.

Botany

It is erect, branched, annual, 25-50 cm. tall plant. In it, 9-15 pairs of leaves are present. Imparipinnate, serrate margin is present. These have a high amount of the oxalic and malic acids. Flowers are white or pink. Pods have 1-2 seeds. Seed coat is wrinkled, smooth or rough, yellow red or brown in colour.

Cultivation

It is sown in October. It is adapted in arid and semi arid region, and also in dry regions and regions having low rainfall. In frost condition, crop gets destroyed. It is grown in clay soil. Seeds contain 9.8% moisture, 17.1% protein, 5.3% fats, 61.2% carbohydrates, 3.9% fibre, 7.2% minerals.

Uses

Chickpea is the most nutritious pulse crop. Seeds are eaten as raw, as baked or boiled. From its flour, sweets and spicy dishes are prepared. Its leaves and stems are used as fodder. Its germinated seeds are used to prevent scurvy disease.

3. Phaseolus Aureus

Family- Leguminosae

Common name- Green gram/ Mung

Origin centre- Asia (India)

Botany

It is grown in South-east Asia, Africa, West Indies and USA. Plants are erect/sub erect, branched, annual, 50-30 cm. in height. Leaves are alternate and trifoliate, compound. Yellow flowers grow in groups. Pods are gray-brown, which have 10-15 seeds, which are green or yellow.

Cultivation

It is fast growing, warm season dry land pulse, which matures in 3-4 months. It is grown on a wide variety of soils but thrives best on a good loam, requiring a rainfall of 75-90 cm. per year. It is cultivated mainly as Kharif (summer) crop in India. It is cultivated from sea level to an altitude of 3725 m.

Uses

It is mainly used in human diet, which is eaten as seeds or pulse. It is easily digested. Chinese and Americans eat it as germinated seeds. In India, it is eaten in tea or taken as fried with drink. Broken seeds are used as fodder. It has protein 23.7%, fats 1.2%, carbohydrates 58.2%, fiber 3.3% and minerals 4.0%.

4. Phaseolus Mungo

Family- Leguminosae

Common name- Black gram

Origin centre- India

It is mainly cultivated in tropical countries, such as east Africa, India, Malaysia. In India, M.P. is the biggest producer.

Botany

It is black gram, fast growing, erect and annual and 18 cm. long herb. Long and red brown hairs surround leaves and stem. Hence, it is also called as woolypyrol. Leaves are bigger, trifoliate and leaflets are lanceolate. Flowers are smaller, yellow and spiral. Pods are narrow, cylindrical and septate. These have 6-10 seeds, which are black and green. Seed coat is smooth.

Cultivation

This crop grows in warm climate under 90 cm. rainfalls. It is best grown in black cotton soil. It is grown as both Rabi and Kharif crop. Crop matures in 3-4 months.

Uses

It is phosphoric acid rich crop. Its seeds are used for weighing as Mashaatola. Its main use is in making papad, badi. In South India, it is used for making fermented food. It is also mixed in bread and biscuit. Plant is given as fodder to the animals. Dried pulse contains 9.7% moisture, 23.7% protein, 1% fat, 57.3% carbohydrates, 3.8% fiber and 3.4% minerals.

Vegetables

Vegetables are having important food value because it is the source of minerals and carbohydrates, vitamins. Although it is not major source of energy it can be used raw vegetables or after cooking. It grows quickly. Even some crops show world level importance. At present, fresh as well as frozen, dehydrated and canned vegetables are available in the market. Vegetables means which are used after salting and boiling. That's why many fruits like tomato, eggplant, cucumber are regarded as vegetables.

In vegetables, carotene is present which is the precursor of vitamin A. It is present in carrot, sweet potato, spinach, lettuce, Amaranthus, turnip green, muskmelon, and watermelon. Vitamin C is present in Brussels sprouts, broccoli, lettuce, tomatoes, peppers, cabbage, cucumber. Vitamin E is present in spinach.

Similarly minerals are present in vegetables. Potato, sweet potato and onion are rich in phosphorous. Spinach, beans, lettuce, onions, tomatoes and cabbage are calcium rich. Soyabean, spinach, brinjal, peas, chillies, raddish, garlicand tomatoes are the source of iron. Legumes contain calcium, iron, potassium which are acid neutralizers. Vegetables are also the source of roughages having higher percentage of cellulose material. It satisfies appetite, helps in movement of food in the alimentary canal and prevents constipation. Some important vegetables are as follows:

1. **Potato**

   Botanical name- *Solanum tuberosum*

   Family-Solanaceae

   Origin- Highlands of Peru and Bolivia

It was the important food of Incas and they started its cultivation. Later Spanish introduced it in Europe. In India, Portuguese brought it.

Botany

It is herbaceous annual crop. Aerial stem is erect. Potato is underground part. Food is accumulated into underground stem, which is starch and widely used. It contains 70-80 % water, 10-30 % carbohydrates, 1-3% proteins, 2-3 % fibres, 0.1 % fats.

Cultivation

It requires cool nights and warm days during tuber formation. Irrigation or rainfall is needed just before tuber formation.

Uses

It is used as vegetable chips, potato flour, frozen French fries and microbial culture medium.

2. Sweet Potato

Botanical name- *Ipomea Batata*

Family- Convolvulaceae

Origin- Tropical America

Evolution

It is hexaploid plant. It has been evolved from hybridization of *Ipomea tiliaceae* and *I. fastigiata*. So diploid and tetraploid species are related with its evolution. It is propagated through stem cutting or through tubers (budding). Harvesting is done within 4-6 months.

Composition

Water 70%, carbohydrates 27%, fats 0.2%, proteins 1.5-2.0%, fibres 1%.

3. Taro

Botanical name- *Colocassia*

Family- Araceae

Origin- India and Polynesia

Botany

Plant is 2-3 m long. Leaves are spirally arranged. Flowers are unisexual.

Cultivation

It is cultivated in tropics. Cultivation requires moist, well-drained soil. High rainfall is necessary.

Composition

Water 60-80 %, carbohydrates 13-30. 5%, proteins 1.5-3.0 %, vitamin C, thiamine, riboflavin and niacin are present in trace amount.

Uses

It is used as baby food, flour, chips and it is easily digested.

4. Onion

Botanical name- *Allium cepa*

Family- Alliaceae

Origin centre- Mediterranean

Botany

It is herbaceous plant. Tubular leaves are present. Underground modification (modification of rhizome) is present. It is a biennial crop. Bulb is made up of short stem, surrounded by fleshy leaf bases. It is long day plant. Scapigerous inflorescence is present. Plant is 60-90 cm tall.

Cultivation

Varieties are adapted in colder region/temperate region. Harvesting is done within 3–5 months. It needs light sandy or silt loam soil. Long photoperiod is needed for bulb formation.

Composition

Moisture 86%, protein 1.4%, fats 0.2%, carbohydrates 11%, fibers 0.3%, minerals 0.6% are present.

Uses

It is used as salad; in soups, ketchups, sauces, curries, chutney, and pickles; as flavoring agents.

5. Turnip

Botanical name- *Brassica Rapa*

Family- Brassicaceae

Origin- Central and Southern Europe

Botany

Plant is herbaceous, rough hairy leaved, and biennial. Large swollen roots are present. Raceme inflorescence is present.

Cultivation

It is quick maturing crop, cool season crop and grown in climacteric soil.

Uses

It is having higher percentage of starch. It is used as cooked vegetable.

6. Carrot

Botanical name- *Daucus Carota*

Family- Umbellifereae

Origin- Europe, Africa, Asia

Evolution- Evolved from wild carrot

Botany

Plant is erect, biennial, 30-100 cm in height. Thick conical taproot, pinnately compound leaves are present. Stem is small plate like. Inflorescence is compound umbel.

Cultivation

It is cool season crop grown in deep, moist, loose, light loamy soil. Seeds are sown on ridges. Cultivation is expensive.

Uses

It is carotene rich and used as salad, curries, sauce, pickle, halwa etc.

7. Beet root

Botanical name- *Beta vulgaris*

Family- Chenopodiaceae

Evolution- evolved from *Beta maritime* (wild)

Origin centre- Coastal Europe, North Africa and Asia Minor.

Botany

It is biennial plant with thick roots, rosette leaves. Seeds and flowers are obtained during second year. Roots become thick due to cambial activity. Primary and secondary bundles are present.

Cultivation

Plant is adapted in temperate climate, aerated deep and moist soil.

Uses

It is used as cooked vegetable.

8. Radish

Botanical name- *Raphanus sativus*

Family- Brassicaceae

Origin centre- Asia

Botany

Annual herb, height is 60-75 cm. Leaves are simple, alternate, inflorescence racemose raceme, corolla cruciferous, stamens tetradynamous. Fruits are siliqua.

Uses

It shows low food value, high percentage of pectin. Roots are used as vegetable and salad.

9. Asparagus

Botanical name- *Asparagus officinalis*

Family- Liliaceae

Origin centre- Asia minor

Botany

Plant is herbaceous, dioecious, perennial, 1-3 m tall and with fibrous roots.

Composition

Water 95%, vitamin A, B1, B2 and C are present.

Uses

It is used as cooked vegetable.

10. Cauliflower

Botanical name- Brassica Oleracea

Family- Brassicaceae

Origin centre- Not clear but wild species is obtained from chalky coast of England, West and South coast of Europe.

Botany

Plant is biennial, large, compact, condensed with swollen head at the top. Large leaves are present.

Cultivation

It is cool season crop, adapted in cool, moist, temperate zone, grown in clay, silt or loamy soil.

Uses

It is used as a cooked vegetable.

11. Lettuce

Botanical name- *Lactuca Sativa*

Family- Compositae

Origin centre- Southern Europe

Botany

Plant is annual/biennial herb. Smooth and rosette, spiral leaves are present. Homogenous capitulum inflorescence is present.

Uses

It is used as salad.

12. Spinach

Botanical name- *Spinacea oleracea*

Family- Chenopodiaceae

Origin- South-west Asia

Botany

It is annual crop, leafy vegetable, Vitamin A and C rich, protein rich. Leaves are smooth, large and dark green.

Uses

It is used as salad as well as cooked vegetable.

Some other important vegetables are-

1. Bottle guard

Botanical name- *Lagenaria vulgaris*

Family- Cucurbitaceae

2. Chillies

Botanical name- *Capsicum*

Family- Solanaceae

It is vitamin C rich.

3. Tomato

Botanical name- *Lycopersicon Esculentum*

Family- Solanaceae

Origin- Mexico

It is vitamin A and C rich.

4. Brinjal

Botanical name- *Solanum Melongena*

Family- Solanaceae

Origin- North-east India.

It is iron rich.

5. Ladyfinger

Botanical name- *Hibiscus Esculentus*

Family- Malvaceae

Origin- Tropical Africa

Forage Crops

All the pulse crops are categorized in the forage crops, which are protein rich. These crops are having root nodules and can fix the nitrogen, so it also increases soil fertility. Details of the crops are given in the fodder crops.

Fodder Crops

Those crops which specially grown for animal feed is known as fodder crops. These are nutrient rich crops, which can increase up milk yielding efficiency. Many crops are grown as fodder crops like maize, alfa-alfa, triticle, secale cereale etc. Majority of crops belong to graminae family. Green fodder contains sufficient amount of protein and calcium. In India

Table 2.1

S.No.	Area	Species
1	North-west region	1. Acacia Nilotica 2. Salix Tetrasperma 3. Capparis Spinosa 4. Ficus Carica 5. Prosopis Species
2	Indogangatic plain	1. Acacia Tortilis 2. Cassia Fistula 3. Sesbania Grandiflora 4. Zizyphus Zuzuba 5. Artocarpus Integrifolia 6. Grewia Oppositifolia 7. Morus Sp.
3	Central zone	1. Azadirachta Indica 2. Moringa Pterigosperma 3. Pterocarpus Marsupium 4. Syzygium Cumini
4	North-eastern zone	1. Bambusa Sp. 2. Tinospora Cardifolia 3. Morus Alba 4. Delonix Elata

forest and waste land is used as fodder zone. Mainly these are developed as grassland pastures. Main crops are *Dichanthium, Setaria, Cynodon, Sporopoblus, Heterodon, Sehima, Cymbopogon* etc. Some important fodder trees are following:

Fiber Crops

Fibers are long narrow cells. Its diameter is less, and its lumen is narrow and cell wall is thick. Its pits are oblique, and present in bundles. Its average length is 1-3 mm. The ramie fibers are strong fibers, which are 55 cm. in length. Cell wall is made up of purely cellulose. It is also having lignin, hemicelluloses and pectin. Small percentage of minerals, fats and waxes are also present.

Classification of Fibers

1. On the basis of nature and structure-
   a) **Bast fibers:** These are made up of phloem, pericycle and cortex. It is known as stem fiber, bast fiber or soft fiber, like, flax, jute, hemp, ramie etc.
   b) **Structural fibers:** These are known as hard or leaf fibers. These are small short lignified fibers made up of xylem and phloem. Fibro vascular bundles serve s unit of fiber, like, Manila hemp, sisal.
   c) **Surface fibers:** These are present at the surface of stem, leaves, fruit and seeds, like, cotton.
2. On the Basis of use
   a) **Textile fibers:** These are used for the manufacture of fabrics, nets and cordage. Firstly, fibers are twisted into threads and then woven as clothes, like, cotton, flax and hemp.
   b) **Brush fibers:** Twigs, leafs and barks are used as brush fibers, like, sisal.
   c) **Plaiting and rough fibers:** These are elastic fibers used in hats, sandals, baskets, chairs, matting etc. It is obtained from palm like leaves.
   d) **Filling fibers:** These are used in cushions and mattresses, like, cotton and jute.
   e) **Natural fibers:** These are obtained from bark and used in rough clothing, like, paper mulberry.
   f) **Paper making fibers:** These are used in paper products. These include wood fibers and textile fibers.

Some Important Fiber Crops

1. Cotton

Botanical name: *Gossypium Hirsutum*

Family: Malvaceae

Origin centre:.S. Asia and Central America

Botany

Plant is monopodial in growth. Leaves are spirally arranged. Branching is dimorphic. Leaves are present at vegetative branches and flowers at reproductive branches. Leaves are palmately lobed and surrounded by multicellular stellate hairs. Flowers are surrounded by involucre and epicalyx. Stamens are kidney-shaped and monothecous. Fruits are having 3-5 locules. Seeds are covered with hairs.

Cultivation

It is cultivated in the new world as well as old world. It needs minimum 200 days for cultivation. Temperature should not be less than 21°C and not more than 43°C. Rainfall should be approximately 100 cm. It is grown in black cotton soil.

Uses

Fibers are used for clothes making etc.

2. Flax

Botanical name: *Linum Usitatissimum*

Family: Linaceae

Origin centre: Mediterranean, Southwest Asia

Botany

It is annual plant. Leaves are ovate and lanceolate. Inflorescence is leafy raceme or open cymes. Fruits are capsule. Flowers are blue-coloured. Fibres are short and brittle.

Cultivation

It is the crop of temperate climate. Climate should be frost free and heavy rainfall-free. It needs high amount of chemical fertilizers. Soil should be well-drained loam or clay loam. The pH is in between 5.0 to 7.0. Moisture should be high and temperature should be low.

Uses

It is used in fabrics- cambrics, lace, linen etc.

3. Hemp

Botanical name: *Cannabis Sativa*

Family: Cannabinaceae

Origin centre: Central and west Europe

Botany

It is tall, hollow, annual crop. Leaves are dark green, palmately compound and with seven serrate leaflets. Female plant is shorter with terminal leaves. Male plant is taller with few leaves. Male flowers are axillary; female flowers are sessile. Male flower dies away after flowering, while female plants are destroyed 20-40 days after pollination.

Cultivation

It is grown in temperate countries. It is grown in wide range of climate and soil. Climate should be mild, humid and temperature should be 17-27°C. Soil should be loamy. It needs thinning.

Uses

It is used in carpets, canvass, twine, rope.

4. Jute

Botanical name: *Corchorus*

Family: Tiliaceae

Origin centre- Ancient Egypt and Meditteranean

Botany

It is woody, branched plant, and it is annual plant. Flowers are solitary or with cymose inflorescence. Its leaves are having chorchorin glycoside. Flowers are yellow, small and globular. Fruits are capsule.

Cultivation

It is rainy season crop. It needs warm, humid climate and loamy or alluvial soil. Rainfall should be 150-250 cm. and temperature should be in between 17-38 °C.

Uses

It is used for bagging and wrapping textile.

5. Sunn hemp

Botanical name: *Crotolaria Juncea*

Family: Leguminosae

Origin centre: Asia

Botany

It is tall, erect, annual and 1-3 m. high plant. Nodules are present in the roots. Vegetative parts are covered with hairs. Leaves are small, lanceolate, subsessile and alternate. Flowers are small, yellow and inflorescence is racemose type. Fruits are pod type. Seeds are kidney-shaped.

Cultivation

It is the crop of tropical and sub-tropical region. Soil is light, loamy. Rainfall is 50-75 cm and temperature is average.

Uses

It is used as cordage fiber.

6. **Manila hemp**

Botanical name: *Musa Textilis*

Family: Musaceae

Origin centre: Philippine island

Botany

It is similar to banana plant. It is having underground rhizome and surface feeder roots. It shows pseudostems having 6.1 m height. It is made up of 15-25 leaf stalks. Lamina is large.

Cultivation

It is a crop of wet tropical climate. Rainfall is 250-275 cm. Humidity is high. Temperature is 27-30 °C. It cannot grow in water logging condition. It is propagated with the help of suckers. Suckers are sown in the depth of 5-10 cm.

Uses

It is used in marine cordage, in fishing industry, paper industry etc.

7. **Sisal**

Botanical name: *Agave Sisalana*

Family: Agavaceae

Origin centre: Mexico

Botany

It is short, thick stemmed plant. Leaves are rosette. These are lanceolate, sessile and approximately 1m long. Leaf bases are bulbous.

Cultivation

It is adapted in arid environment. It grows in dry, arid, sandy, loam soil. It needs high temperature and 100-125 cm rainfall.

Uses

It is used for binder and baler twines, carpet bags etc.

8. **Coconut**

Botanical name: *Cocos Nucifera*

Family: Palmae

Origin centre: Indo Pacific region

Botany

It is long tropical and sub-tropical plant. Leaves are present at the apex. Stem is covered with leaf scales. Fruits are drupe. Leaves are pinnately compound. Stem is woody, solid and cylindrical. Flowers are grey coloured.

Cultivation

It is grown near the coastal area. Soil is sandy, loam. Temperature is 25-40 °C. Moisture is less.

Uses

It is used for commercial coir and coir products.

9. Kapok (Silk cotton)

Botanical name: *Ceiba Pentandra*

Family: Bombaceae

Origin centre: Tropical America

Botany

It is tall, deciduous tree. Height is 10-30 m Leaves are compound with sessile leaflets. Small white/pink flowers are present in groups. Fruits are leathery capsule, which are 10-30 cm long. Seeds are dark brown. Tree becomes leafless.

Cultivation

It grows in wide range of climate. Rainfall is 125-150 cm. Temperature is 18-28 °C. Soil is volcanic clay type. Fruits cannot ripe up, if temperature is less than 19 °C.

10. Ramie/China grass

Botanical name: *Bohemeria Nivea*

Family: Urticaceae

Origin centre: China, Japan, Malaya

Botany

It is tall, perennial plant. Leaves are simple, alternate, petiolate and heart-shaped. Flowers are small, green yellow or pink.

Cultivation

It grows in wide range of climate. Soil is sandy loam with high amount of nutrients. Temperature is high; rainfall should be more than 112 cm. It needs heavy fertilization.

Uses

It is used in Chinese linen-clothes, towels, ropes, twines etc.

Medicinal and Aromatic Plants

Plants are being used as medicines since ancient times. Rig Veda is related with medicinal plants. Charak-Samhita and Susrut-Samhita are also important literatures on Ayurvedic system. Greeks and Romans were also familiar with medicinal plants. Hippocrates, Aristotle and Theophrastus also described medicinal plants. Hippocrates is known as "Father of Medicine". Dioscoroides proposed a book 'Demateria Medica', which is supreme authority of medicine. The medicinal plants are used in different systems, like- Ayurvedic, Homeopathic and Unani. Now-a days, Allopathy is also based on herbal treatments.

Some important medicinal and aromatic plants are as follows:

1. **Belladona**

   Botanical name: *Atropa Belladona*

   Family: Solanaceae

   Origin centre: Central and south Europe and Asia Minor

Botany

It is perennial herb. Height is 90-120 cm. Leaves are ovate. Flowers are purple and bell-shaped.

Cultivation

It is grown in the warm and shady places. Soil is light, calcareous and loamy type. Soil should be humus and mineral rich. Temperature and moisture should be average.

Uses

It is used for treating whooping cough and asthma, in eye testing for dilation of pupil and stimulant of circulatory and respiratory system.

2. **Quinine**

   Botanical name: *Cinchona*

   Family: Rubiaceae

   Origin centre: South America

Botany

It is evergreen shrub. Leaves are simple, opposite and entire stipule is interpetiolar. Flowers are smaller. Inflorescence is terminal panicle and fruits are capsule.

Cultivation

Plants are grown at the altitude of 760-2750 m. Climate is cool and grown at mountain slopes. Rainfall should be more than 220 cm. Soil should be light and organic matter rich. PH is 4.5 to 6.5. It is cultivated through grafting or cutting.

Uses

It is used for malaria fever, as tonic, antiseptic, insecticide and preservative.

3. Foxglove

Botanical name: *Digitalis Purpurea*

Family: Scrophulariaceae

Origin centre: Central and South Europe

Botany

It is biennial herb. Leaves are rosette type. Flowers are zygomorphic, tubular, purple or yellow.

Cultivation

It grows in cool and moist climate. In India, it is cultivated in Kashmir and Nilgiri hills. Soil should be loamy and organic matter rich. Rainfall should be more than 200 cm.

Uses

It is stimulant of heart and is used in the treatment of cardiac and circulatory disorders.

4. Ephedrine

Botanical name: *Ephedra Sp.*

Family: Ephedraceae

Botany

It is perennial, shrub like plant. Leaves are scaly and present at node. Branches possess nodes and internodes. Its flowers are basically cone.

Cultivation

It is arid region plant. It is grown in the desert area. It needs high temperature and low rainfall.

Uses

It is used in nasal drops, bronchial coughs, asthma etc.

5. Opium

Botanical name: *Papaver somniferum*

Family: Papaveraceae

Origin centre: Asia minor and India

Botany

It is annual herb. Leaves are large, alternate and simple. Flowers are bimarous. Colour is yellow. Alkaloids are present in stem and fruits. Fruit is capsule type.

Cultivation

It is the tropical and sub-tropical plant. It is Rabi crop. Seeds are sown in October-November, when temperature is low and moisture is high. Fruits are collected in March-April, when temperature is high. Soil is sandy loam type.

Uses

It is used as hypnotics and sedatives.

6. **Rauwolfia**

Botanical name: *Rauwolfia Serpentina*

Family: Apocynaceae

Origin centre: India, Bangladesh, Srilanka

Botany

It is evergreen, herbaceous plant. Root is tuberous. Leaves are simple, lanceolate and whorled. Inflorescence is terminal and cymose type.

Cultivation

It is sub-tropical plant. So cultivated all over India, but dominant in Himalayan region. It needs high moisture and average temperature. Rainfall should be more than 75cm. pH should be 4.0-6.0. Soil should be humus rich. It is propagated through root or stem cutting.

7. **Nux vomica**

Botanical name: *Strychnos nux-vomica*

Family: Loganiaceae

Origin centre: Phillipine island

Botany

It is small tree-like plant. Leaves are oval and shows multicostate venation. Fruits are berry type and each fruit is having 3-5 seeds. Seeds are hard, large, circular and flat. Seeds are covered with hairs.

Cultivation

It is temperate plant, so cultivated in the cool and moist climate. Soil should be humus rich.

Vegetable Oil-yielding Crops

Oils are the esters of glycerol and unsaturated fatty acids. These are having carbon, hydrogen and oxygen; percentage of oxygen is low.

Its chemical formula is-

$$\begin{array}{l} CH_2COOR_1 \\ | \\ CHCOOR_2 \\ | \\ CH_2COOR_3 \end{array}$$

The important acids present in the oil are-

i)	Oleic acid	$C_{18}H_{34}O_2$
ii)	Linoleic acid	$C_{18}H_{32}O$
iii)	Linolenic acid	$C_{18}H_{30}O_2$
iv)	Ricin oleic acid	$C_{18}H_{34}O_3$
v)	Erucic acid	$C_{22}H_{42}O_2$

Classification of Vegetable Oils

a) **Non-drying oils:** These occur as liquid at all temperatures. These do not react with oxygen. Generally, these are having oleic acid. Iodine no. is less than 100. It is not oxidized, so film is not produced. These are used as cooking oils, like- groundnut, palm oil, rapeseed oil and almond oil.

b) **Semi-drying oils:** It is intermediate between drying and non-drying oils. It is having high percentage of linoleic acid. It slowly absorbs oxygen from atmosphere, and produces soft film. Iodine no. is 100-130; as- sunflower, cotton seed oil.

c) **Drying oils:** These are rich in unsaturated fatty acids, like linoleic and linolenic acid. It absorbs oxygen quickly and forms tough and resistant film. Its iodine no. is more than 130, like linseed, soyabean, safflower.

Location of Oils

It is present as small insoluble drops in plant cells. It occurs in seeds, especially in endosperm and cotyledons. Olive and palm oil is extracted from pericarp of the fruit.

Important Vegetable Oil-yielding Crops

1. Arachis Hypogea

Common name: Groundnut

Family: Leguminosae

Origin centre: Brazil

Botany

Annual herb, simple, opposite leaves, 30-60 cm. tall, flowers are yellow, sessile and present in groups. Ovary monocarpellary. Fruits long having 1-3 seeds. Fruits are hypogeal, seeds are nonendospermic, oil present in cotyledons. Seed having 26% protein and 45% oil. It is rich in thiamine, riboflavin and niacin rich. It is the second largest source of oil.

Cultivation

It is tropical crop. It is warm season crop. It needs much more sunshine. Rainfall is more than 100 cm. It needs frost free growth period. Soil should be dry, sandy, loam.

Plant part used: Seed

2. Brassica Campestris

Common name: Rape, Mustard

Family: Cruciferae

Origin centre: Mediterranean

Botany

Annual herb, height is 60-75 cm. Leaves are simple, alternate, inflorescence recemose receme, corolla cruciferous, stamens tetradynamous. Fruits are siliqua.

Cultivation

It is winter season crop. It is grown during rainy season. It needs average temperature and rainfall. Soil should be humus rich, and clay, loam.

Plant part used: Seed

3. Cocos Nucifera

Botanical name: *Cocos Nucifera*

Family: Palmae

Origin centre: Indo Pacific region

Botany

It is long tropical and sub-tropical plant. Leaves are present at the apex. Stem is covered with leaf scales. Fruits are drupe. Leaves are pinnately compound. Stem is woody, solid and cylindrical. Flowers are grey coloured.

Cultivation

It is grown near the coastal area. Soil is sandy, loam. Temperature is 25-40 °C. Moisture is less.

Plant part used: Endosperm

It is used for commercial coir and coir products.

4. **Elacis Guineenis**

Common name: Oil palm

Family: Palmae

Origin center: W. Africa

Botany

It is erect tree; height is leaf bases surround 20 m stem. Leaf length may be 3-5 m male and female flowers are interfoliar. Inflorescence is compound spike/ spadix. Flowers are trimerous. Plants are unisexual.

Cultivation

It is arid zone crop. It is grown in well-drained sandy soil. Rainfall may be low. Temperature should be high. Its oil is having myristic acid, palmitic acid, stearic acid, oleic acid and linoleic acid.

Plant part used: Mesocarp of fruit

5. **Olea Europea**

Common name: Olive oil

Family: Oleaceae

Origin centre: West Asia

Botany

It is narrow leaved, xerophytic tree. Height is 15 to 18 cm. Fruits are one seeded drupe. Fruits are green coloured later becomes red and black. Oil is extracted from epicarp or mesocarp.

Cultivation

It is grown in warm and dry areas. Temperature should not be less than 18ºC at-5ºc. It grows in semi arid region. Rainfall is 60-75 cm. Best growth occurs in calcareous sandy loam. It is having 65-75% oleic acid and 7 to 20% palmitic acid.

Plant part used: Fruits

6. **Ricinus Communis**

Common name: Castor

Family: Euphorbiaceae

Origin centre: N. Africa

Botany

It is tall, perennial plant. Height 9-12 m nodes and leaf scars are present. Growth cycle is completed in 150-180 days. Leaves are palmately lobed. Leaves are alternate with multicostate venation. Plant is monoecious. Inflorescence is cyathium fruits are capsule.

Cultivation

It needs average temperature and rainfall. It is sub tropical. Temperature should be 20- 30 °C. Soil is sandy or clay loam. Rainfall is 60-90 cm. Caster oil is having 90-95 % ricin oleic acid.

Plant part used: Seed

7. **Gossypium sp.**
   Common name: Cotton
   Family: Malvaceae
   Origin centre: South East Asia, Central America

Botany

Plant is monopodial in growth. Leaves are spirally arranged. Branching is dimorphic. Leaves are present at vegetative branches and flowers at reproductive branches. Leaves are palmately lobed and surrounded by multicellular stellate hairs. Flowers are surrounded by involucre and epicalyx. Stamens are kidney-shaped and monothecous. Fruits are having 3-5 locules. Seeds are covered with hairs.

Cultivation

It is cultivated in the new world as well as old world. It needs minimum 200 days for cultivation. Temperature should not be less than 21°C and not more than 43°C. Rainfall should be approximately 100 cm. It is grown in black cotton soil.

Plant part used: Seed

8. **Glycine Max**
   Common name: Soyabean
   Family: Leguminosae
   Origin centre: China

Botany

Annual herb, trifoliate simple leaf, height is 60-180 cm, and leaflets are lanceolate. Flowers are small, root nodule are present in roots. Seeds are small and fruits are pods.

Cultivation

It is sub-tropical and winter season crop. It is grown during rainy season. During fruiting the weather should be dry. Very high or low temperature is harmful. Soil should be deep, fertile and calcium rich. It is matured within 75-110 days.

Plant part used: Seed

9. Sesamum Indicum

Botanical name: Sesame

Family: Pedaliaceae

Origin: Africa as primary centre and India as secondary centre of origin.

Botany

Erect, annual and bushy plant. Its height is 2 meters. Leaves are broad and lobed. Flowers are bell shaped and white or pink in colour.

Cultivation

It is grown in hot, dry tropics. Rainfall must be 50-110 cm. Temperature should be 21-40°C. It is a Kharif crop. It matures within 100-140 days. Seeds are having 20-25% proteins and 50% oil. Oleic acid is 37-50% and linoleic acid is 37-47%. It is used in Ravari and Gajak.

Uses

Seeds are used in bread rolls and in bakery. It is spread out at the top of bread, pastries and cake. Its Laddus are eaten on Makar Sakranti.

Important Fire-wood and Timber-yielding Plants and Non-wood Forest Products

From ancient times, wood is used as fuel and timber. It is obtained from forests and that's why man's economy is based on forests. Now-a-days also, tribal and villagers are based on forests. Tribal collect different forest products and get the employment. Generally, plants, which are cut from the forests, are used as timber, fuel and fodder. The land area of the world is 1.3 x 1010 hectares, in which forest area is 4.1 x 109 hectares. At the world level, 2.4 x 1011 m3 standing timber is available, in which 1.14 x 1011 m3 is coniferous wood, and remaining is non-coniferous hard wood. It means 33% forest area is present in cold regions. Indian forest is non-coniferous. In India, about 70 crore-hectare forests are available, which is about 20% of total area. Conifers are present only at Himalayan region. The important conifers are *Pinus Walluchiana, Pinus Roxburghii* and *Cedrus Deodara*. Among the hard wood species, teak (*Tectona Grandis*), sal (*Shorea Robusta*), laurel (*Terminalia Tomentosa*), gurjan (*Dipterocarpus*) and sheeshum (*Delbergia Sissoo*).

Wood

Wood is generally strong. Its strength is similar to iron and 5 to 6 times stronger than cement. It is cheaper, lighter and can be moulded easily. It can be altered or rebuilt. We can make the beautiful design and it is rust-resistant.

Anatomical Characters

Mainly, wood is made up of secondary xylem. It is produced by cambial activity. In the xylem, tracheids, vessels, fibres and parenchyma occur. Fibres may be libriform or gelatinous. When the wood is having large vessels like holes, then it is known as porous wood. Except *Trochodendroa, Tetracentron, Drimys, Pseudowintera*, these are veselless, wood, while in *Acer, Populus, Betula*, vessels are uniform. It is known as diffused porous wood. In many woods, gum ducts are present as in dicots, or resin canals are present as in gymnosperms. In the gymnosperms, typical fibers are absent. So wood is known as soft wood, while angiosperm wood is hard due to the presence of fibers. Similarly, in the spring season, large cells are cut down, which are thin walled and called as spring wood, but in autumn season, due to the lack of supply, small cells are cut down which is known as autumn wood. Each year one ring of autumn wood is formed, which is called as growth ring. The texture of wood is based on its elements. Large vessels wood is known as coarse wood, while if vessels are small, then it is known as fine wood. When fibers are parallel in wood, then known as straight-grained wood.

Properties of Wood

1. Moisture- Wood is hygroscopic in nature. It may be 30-200%. Sapwood is having more moisture than hard wood. Wood water is present, hygroscopic form or as free water. The timber wood is dried before use, which may be airdrying or kiln- drying.
2. Density- It shows amount of cell wall per unit volume. For timber use, high-density wood is useful. Its range may be 0.04 to 1.40. If density is less than 0.5, then known as lightwood and if more than 0.7, then known as heavy wood.
3. Durability- The ability of wood to resist the decay is known as durability. Mainly, fungi and insects decay wood. The wood of red cedar, *cyperus*, red wood, chestnut wood is durable.
4. Thermal property- Wood is poor conductor of heat, sound and electricity. So, it is used as building material.
5. Strength- The response of wood against any force is called as strength. Tensile strength is mainly resistant to force, shearing strength is resistant to tear.
6. Hardness- It is resistant to deformation.

Important Timber-yielding Plants

1. Delbergia Sissoo

   Common name: Sheeshum

   Family: Leguminosae

   Property- Finest furniture wood.

2. *Diospyros*

Common name: Ebony

Family: Ebenaceae

Property- Used for decorative purposes.

3. *Shorea Robusta*

Common name: Sal

Family: Dipterocarpaceae

Property- Heartwood is hard, heavy, tough and most durable timber wood and used in flooring and railway sleepers.

4. *Swietenia Mahogany*

Common name: Mahogany

Family: Meliaceae

Property- It is reddish-brown type. Wood is diffused porous type. It shows light-reflecting quality, and is mainly used in cabinets and blocks.

5. *Tectona Grandis*

Common name: Teak

Family: Verbenaceae

Property- It is durable, hard and resistant wood. Hardwood is golden-yellow and immune to attack, so best wood for furniture.

6. Cedrus Deodara

Common name: Cedar

Family: Pinaceae

Property- Vessel less wood, it is strongest soft wood. Its sap wood is white and hard wood is yellow. Timber is durable and resistant. It is used in structural work.

7. Pinus

Common name: Pines

Family: Pinaceae

Property- It is vessel less wood. Wood is hard and yellow, or soft and white. But it is not strong or durable. So it is used in crates, boxes and rough work.

Important Firewood Plants

Fuel is the primary need of a man. It is used for heating and cooking. Wood, coal and petroleum are known as fossil fuels, which are obtained from the forests. Wood is known as renewable resource, while petroleum is non-renewable resource. Any material, which will burn in air, is used as fuel. Following types of fuels can be used.

Wood Fuel

Now-a-days, less wood is used as a fuel, but it is important fuel for villagers and tribal. The 99% oven-dried wood is the best fuel. It leaves only 1% ash, and remaining material gets changed into heat, because if percentage moisture is higher in the wood, then major part of heat is consumed in the vaporization, like *Ulmus* is unburnable in green condition, but in the dry condition, it is the best fuel. The *Ilex Opaca* and *Fraxinus* are having low moisture, so can be burnt directly. The knotty soft wood burns rapidly, so it should be guarded when fired in open place. The best fuel woods are hard wood like beech, oak, birch and maple. The calorific value of wood is 4600 calorie/kg. It is 50% of that of the coal. Wood also has different combustible material, like-resins, oil, and gum.

Fossil Fuel

a) **Peat**- It is deposits of vegetable matter. Mainly, it is made up of mosses, like sphagnum. It decomposes slowly. In some parts of the world, peat is compressed, dried and burnt. It produces large amount of ash.

b) **Coal**- It is fossilized plant remains. It is formed due to slow decomposition. These are formed due to high pressure of rocks and internal earth heat. There the limited supply of water and air is also important. In this condition, plant structure gets changed into pure carbon. Coal is harder and compact than peat. It shows very high heat power. Anthracite coal has 95% carbon. Bituminous coal is having less percentage of carbon. It is the cheap source of heat and power generation. After distillation, it gives many products, like coke, benzol, naphtha, coal tar, dyes etc.

c) **Petroleum**-It is formed due to high pressure on plant and animal life. It is present in liquid form and after distillation; it gives many products, like gasoline, kerosene, petroleum jelly, paraffin etc.

d) **Mill residues**- In the mills, saw dust and shavings are produced, which are used as fuel in condensed forms. These are used for domestic cooking.

e) **Wood charcoal**- It is amorphous carbon and obtained from wood. Now-a-days, these are less used. These are obtained through burning wood in the absence of air. These are obtained from hardwood and logs. Charcoal is pure carbon. At many places, charcoal is the important fuel, especially in villages and tribal areas, where LPG is not available.

Resins

Resin is the viscous organic compound. It is the wood product. It is highly inflammable; basically resin is the product of coniferous wood. In the cortex and pith region of coniferous wood, resin canals are present. These resin canals also occur in the root and leaf. These are lysogenic cavities, and made up of secretory cells. This resin generally increases toughness of wood.

Some important plants producing the resin and found in India are as follows:

	Botanical Name	Family	Common Name
i)	*Pinus Wallichiana*	Pinaceae (conifers)	Blue pine
ii)	*P. Insularis*	Pinaceae	Chir pine
iii)	*P. Roxburghii*	Pinaceae	Roxburgh pine
iv)	*P. Girardiana*	Pinaceae	Chilgoja pine
v)	*P. Murskii*	Pinaceae	Yellow pine
vi)	*P. Armandi*	Pinaceae	Armand pine
vii)	*Cycas Revolute*	Cycadaceae (cycads)	
viii)	*C. Circinata*	Cycadaceae (cycads)	
ix)	*Cedrus Deodara*	Conifers	Deodar
x)	*Abies Pindrow*	Conifers	

Dyes

Dyes are used since ancient times. It is the accidental staining from berries, nuts and roots. These are used to dye the wool, linen and other fibers. Even many dyes are used in the food stuffs. First time, the dye was used in tomb painting. Dyes are not chemically pure. These dyes belong to glycosides, quinone and flavones. Till now, more than 2000 types of pigments have been discovered from plants. Some important dye-yielding plants are:

1. Annatto (Orange-red dye)

   Botanical name- *Bixa Orellana*

   Family- Bixaceae

   Pigment- Bixin and orellen

   Nature-Non-toxic

   Use- Used in lipstick, butter, cheese, chocolate.

2. Safflower (Orange-red dye)

   Botanical name- *Carthamus Tinctorius*

   Family- Compositae

   Pigment- Carthamine, safflower yellow and isocarthamine

   Nature-Non-toxic

   Use- Used in staining of cotton and silk; used in cakes and biscuits.

3. Logwood (Purple-red dye)

   Botanical name- *Haemotoxylon Campechianum*

   Family- Leguminnosae

   Pigment- Haemotoxylene, haematin

   Nature- Toxic

   Use- Used in fabric colours and staining dead tissues.

4. Indigo (Blue dye)

   Botanical name- *Indigofera*

   Family- Leguminosae

   Pigment- Indigotine

   Nature- Toxic

   Use- Used in cotton printing, wool dying, printing ink.

5. Heena (Orange dye)

   Botanical name- *Lawsonia inermis*

   Family- Lathyraceae

   Pigment- Lawsone

Tannins

Tannins are generally extracted from stems. Tannins combine with proteins of skin and give stable lather, which is soft, strong and resistant to moisture, air and temperature. Generally, these are glycosides of organic acids and are formed due to metabolism of sugars. These are reducing in nature and water-soluble.

Tannins are catechol and pyragallol type. The natural tannins are the mixture of both the compounds. Some important tannins are as follows:

	Common Name	Botanical Name	Family
i)	Black wattle	*Acacia Mearnsii*	Leguminosae
ii)	Kattha	*Acacia Catechu*	Leguminosae
iii)	Babul	*Acacia Nilotica*	Leguminosae
iv)	Red mangrove	*Rhizophora Mangle*	Rhizophoraceae
v)	Silician sumac	*Rhus Coriria*	Anacardiaceae
vi)	Canaigre	*Rheumax sp.*	Polygonaceae
vii)	Chebulic myrobalan	*Terminalia Chebula*	Combretaceae
viii)	Vilonia	*Quercus sp.*	Fagaceae
ix)	Hemlock	*Tsuga Canadensis*	Pinaceae
x)	Gambier	*Uncaria Gambier*	Rubiaceae

Raw Materials for Paper-making

'Paper' word is derived from papyrus. This plant is grown for decorative purposes and its basic material is used for writing purposes. In the earlier period, the written work was done on rocks and metallic sheets. Later, silk, bark and leaves were used. Now-a-days, cellulose is used for paper-making. For this purpose, pulp is used. For the paper-making, fibrous raw materials are used. 97% papers are made from wood pulp and about 85% wood pulps are derived from conifers, like spruce (*Picea*), firs (*Abies*) and *Pinus*. Beyond it, hard wood is also used, as poplar (*Populus*), birch (*Betula*), *Eucalyptus*. In some cases, textile fibers are also used, like-jute, hemp, sisal. High-grade papers are made from Stipa. In India, the main species are Bamboos, like *Bambusa sp., Dendrocalamus sp., Eulaliopsis sp.*

For the paper-making, pulp is prepared. It is carried out as follows:

1. **Mechanical pulping**

   In this process, debarked wood is defibrated. After grinding, pulp is washed, but here the main problem is lignin.

2. **Chemical pulping**

   In this process, wood chips are cooked. So, lignin, hemicellulose are dissolved and pure cellulose fibers are remained. Then, pulping is carried out by sulphide process, sulphate process or soda process.

After the formation of pulp, it is washed, bleached and lapped. For improving the quality of paper, many compounds are added, like china clay, calcium sulphate, calcium carbonate, titanium oxide. Similarly, for improving the smoothness, soap, wax and starch are used.

Bamboos

Botanical name- *Bambusa officinalis*

Family- Graminae (Poaceae)

Botany

Stem is long, hollow and unbranched. Nodes and internodes are present. Leaves are present at nodes. Leaves are long with parallel venation. Leaves are linear. Roots are adventitious. Stilt roots are also present, which are supporting roots and arise from nodal parts. Its flowers are bisexual, which are trimerous.

Cultivation

Cultivation is carried out through stem cutting. Seeds are produced after long time. It is a tropical plant and grows at moderate temperature and rainfall.

Uses

It can be used in the furniture making, but mainly it is used in paper-making.

Gums

Gum is the crude aromatic secretions of the woody plant. Basically, in the dicots, gum ducts are found at the place of resin duct. These are lysogenic ducts that continuously secrete viscous organic compound. It is secreted in the liquid form, but it quickly becomes air dried and changed into solid. Many dicots secrete the gum, like- *Acacia Nilotica* (Babul), *Acacia Catechu*, *Salix Sp.* (wallows).

Gum is generally hygroscopic in nature and is water-soluble compound. So, it is present as true aqueous solution. It is mineral rich, so used in many foodstuffs. It is having adhesive properties, so used as glue material.

Fruits

True fruits are developed from ovary, which are called as eucarp, but when fruits develop from other than ovary, then known as pseudocarp, like apple. So, if the fruits develop from inferior ovary, then it is always pseudocarp. Ovules are changed into seeds after fertilization. Sometimes fruits are formed without fertilization, which are known as apocarpic fruits. On the basis of number of ovaries, fruits are three types

1. **Simple fruits:** It develops from single ovary of one flower.
2. **Aggregate fruits:** It develops from many ovaries of one flower, like- raspberry and blackberry.
3. **Multiple fruits:** These are developed from whole inflorescence.

Fruits may be fleshy/dry. In the fruits, mainly two layers occur – one is pericarp and the other is seed. Pericarp is hard and seed is edible in dry fruits, like almond, while in the fleshy fruits, seeds are not edible and pericarp is further divided into epicarp, mesocarp and endocarp, and any one part of pericarp is edible.

Some important fruit crops:

1. *Citrus species:*

   Family-Rutaceae

   These fruits are vitamin C rich and different species show different types of fruits, like *Citrus Lemon* (lemon), *Citrus Orientalis* (orange), *Citrus Medica* (Kagaji neebu), *Citrus Reticulata* (menderin). Its edible part is endocarp.

2. *Malus Sylvestris* (apple)

   Family- Rosaceae

   It is pseudocarp. Edible part is thalamus. It is vitamin A rich.

3. *Mangifera Indica* (Mango)

   Family- Anacardiaceae

   Edible part is mesocarp. It is vitamin A rich. It is called as "King of Fruits":

4. *Musa Paradisica* (Banana)

   Family- Musaceae

   It is vitamin A rich. Edible part is mesocarp and endocarp.

5. *Phoenix Dactylifera* (Date-palm)

   Family-Palmae (Arecaceae)

   Edible part is pericarp. It is carbohydrate (sugar rich)

6. *Vitis Vinifera* (Grapes)

   Family- Vitaceae

   It is sucrose rich and vitamin rich. It is largest productive fruit crop. It is used in wine industry largely. Edible part is pericarp.

7. *Anacardium Occidentalis* (cashewnut)

   Family- Anacardiaceae

   Edible part is seed. It is vitamin rich. Its oil is very useful.

8. *Casteina Sp.* (Chestnut)

   Family- Fagaceae

   Seed is edible part. It is carbohydrate and protein rich.

9. *Juglans Sp.* (Walnut)

   Family- Juglandaceae

   Edible part is seed. It is oil-rich crop.

10. *Prunus Amygdalus* (Almond)

    Family-Rosaceae

    Seed is the edible part. It is vitamin rich and oil rich crop.

11. *Pistacia Bera* (Pista nut)

    Family-Anacardiaceae

    Seed is the edible part. It is fat-rich.

Review Questions

1. What do you understand by forage crops?
2. Describe the importance of aromatic plants in our life. What are their uses?
3. What is 'Quinine'? What are its uses?
4. Describe the chemical process for making paper.

CHAPTER 3

GREEN REVOLUTION

LEARNING OBJECTIVES

- ❑ Benefits and Adverse Consequences
- ❑ Expansion of Farming Areas
- ❑ Innovation for Meeting World's Food Demand
- ❑ Plant Used as Avenue Trees
- ❑ Plants for Pollution Control
- ❑ Principles of Conservation
- ❑ Extinction
- ❑ Environmental Status of Plants Based on IUCN

Benefits and Adverse Consequences

"Green Revolution" is a general one that is applied to successful agricultural experiments in many third world countries. It is not specific to India. But it was most successful in India. In the India this process was started after facing famous Bengal famine during 1943. It was the world's worst recorded food disaster happened in 1943 in British-ruled India. In this famine an estimated four million people died of hunger that year alone in eastern India. The initial theory put forward to 'explain' that catastrophe was that there as an acute shortfall in food production in the area. However, Indian economist Amartya Sen (recipient of the Nobel Prize for Economics, 1998) has established that food shortage was due to food hoarding

done by Indian businessman for their profit. Later they sold this food at high rate. After 1947 when India gain freedom from British rule then also food production was in the priority list of Indian government. Because Indian government was working in the shadow of Bengal famine. Another problem was, after independence Indian production was low as compare to it's population. So India was importing the food from other countries, specially from USA. To overcome to this problem Indian government launched huge program for increasing agricultural production. Although, it was not successful till 1967. Actual production was increased between the periods of 1967 to 1978. This period is known as green revolution.

British government also tried to increase the production of India and they established many research organizations for increasing agricultural productions. Hennery Phipps establishes Imperial Agricultural Research Institute in Bihar in 1905, which is now named as Indian Agricultural research Institute (IARI) and shifted in New Delhi. Initially in the IARI 5 research departments were established, which were following:

1. Agriculture and cattle breeding
2. Chemistry
3. Economic Botany
4. Entomology
5. Mycology

Although many efforts were done by Indian government, but from 1947 to 1967 sufficient amount of food was not produced. Efforts until 1967 largely concentrated on expanding the farming areas. But starvation deaths were still being reported in the newspapers. In a perfect case of Malthusian economics, population was growing at a much faster rate than food production. This called for drastic action to increase yield. The action came in the form of the Green Revolution.

There were three basic elements in the method of the Green Revolution:

1) Continued expansion of farming areas;

2) Double-cropping existing farmland;

3) Using seeds with improved genetics.

Expansion of Farming Areas

In India the area of land under cultivation was being increased right from 1947. But this was not enough in meeting with rising demand. Other methods were required. Yet, the expansion of cultivable land also had to continue. So, the Green Revolution continued with this quantitative expansion of farmlands. However, this is not the most striking feature of the Revolution.

Double-cropping Farmland

Double-cropping was a primary feature of the Green Revolution. Instead of one crop season per year, the decision was made to have two crop seasons per year. The one-season-per-year practice was based on the fact that there is only natural monsoon per year. This was correct. So, there had to be two "monsoons" per year. One would be the natural monsoon and the other an artificial 'monsoon.'

The artificial monsoon came in the form of huge irrigation facilities. Dams were built to arrest large volumes of natural monsoon water, which were earlier being wasted. Simple irrigation techniques were also adopted.

Seeds with Improved Genetics

This was the scientific aspect of the Green Revolution. The Indian Council of Agricultural Research (which was established by the British in 1929 but was not known to have done any significant research) was reorganized in 1965 and then again in 1973. It developed new strains of high yield value (HYV) seeds, mainly wheat and rice but also millet and corn. The most noteworthy HYV seed was the K68 variety for wheat. The credit for developing this strain goes to Dr. M.P. Singh and for Indian green revolution credit goes to Dr. Swaminathan.

Benefits of Green Revolution

Statistical Benefits of Green Revolution

1) The Green Revolution resulted in a record grain output of 131 million tons in 1978-79. This established India as one of the world's biggest agricultural producers. No other country in the world which attempted the Green Revolution recorded such level of success. India also became an exporter of food grains around that time.

2) Yield per unit of farmland improved by more than 30 per cent between 1947 (when India gained political independence) and 1979 when the Green Revolution was considered to have delivered its goods.

3) The crop area under HYV varieties grew from seven per cent to 22 per cent of the total cultivated area during the 10 years of the Green Revolution. More than 70 per cent of the wheat crop area, 35 per cent of the rice crop area and 20 per cent of the millet and corn crop area, used the HYV seeds.

4) In some area more than 400% increase in production was recorded. Some important examples are following:

Table 3.1

S.No.	Crops	1960-61 average yield*	Average yield of high yielding crops*	% increase
1.	Rice	10.1	55	554
2.	Wheat	08.5	50	588
3.	Maize	09.2	45	483
4.	Potato	72.5	250	344
5.	Jowar	05.3	25	471
6.	Bajra	02.9	20	689

*Quintals/hectare

Economic Benefits of the Green Revolution

1) Crop areas under high-yield varieties needed more water, more fertilizer, more pesticides, fungicides and certain other chemicals. This spurred the growth of the local manufacturing sector. Such industrial growth created new jobs and contributed to the country's GDP.

2) The increase in irrigation created need for new dams to harness monsoon water. The water stored was used to create hydro-electric power. This in turn boosted industrial growth, created jobs and improved the quality of life of the people in villages.

3) India paid back all loans it had taken from the World Bank and its affiliates for the purpose of the Green Revolution. This improved India's creditworthiness in the eyes of the lending agencies.

4) Some developed countries, especially Canada, which were facing a shortage in agricultural labour, were so impressed by the results of India's Green Revolution that they asked the Indian government to supply them with farmers experienced in the methods of the Green Revolution. Many farmers from Punjab and Haryana states in northern India were thus sent to Canada where they settled (That's why Canada today has many Punjabi-speaking citizens of Indian origin). These people remitted part of their incomes to their relatives in India. This not only helped the relatives but also added, albeit modestly, to India's foreign exchange earnings.

Sociological Benefits of the Green Revolution

The Green Revolution created plenty of jobs not only for agricultural workers but also for industrial workers by the creation of lateral facilities such as factories and hydro-electric power stations as explained above.

Political Benefits of the Green Revolution

India transformed itself from a starving nation to an exporter of food. This earned admiration for India in the comity of nations, especially in the Third World.

Adverse Consequences of Green Revolution (Limitations)

1) Even today, India's agricultural output sometimes falls short of demand. The Green Revolution, howsoever impressive, has thus not succeeded in making India totally and permanently self-sufficient in food. In 1979 and 1987, India faced severe drought conditions due to poor monsoon; this raised questions about the whether the Green Revolution was really a long-term achievement. In 1998, India had to import onions. Last year, India imported sugar.

   However, in today's globalized economic scenario, 100 per cent self-sufficiency is not considered as vital a target as it was when the world political climate was more dangerous due to the Cold War.

2) India has failed to extend the concept of high-yield value seeds to all crops or all regions. In terms of crops, it remain largely confined to foodgrains only, not to all kinds of agricultural produce. In regional terms, only Punjab and Haryana states showed the best results of the Green Revolution. The eastern plains of the River Ganges in West Bengal state also showed reasonably good results. But results were less impressive in other parts of India.

3) Nothing like the Bengal Famine can happen in India again. But it is disturbing to note that even today, there are places like Kalahandi (in India's eastern state of Orissa) where famine-like conditions have been existing for many years and where some starvation deaths have also been reported. Of course, this is due to reasons other than availability of food in India, but the very fact that some people are still starving in India (whatever the reason may be), brings into question whether the Green Revolution has failed in its overall social objectives though it has been a resounding success in terms of agricultural production. The Green Revolution cannot therefore be considered to be a 100 percent success.

4) Continue from 1996 food production is decreasing and population is increasing. In different years different agricultural products are imported. In last four years India has been experiencing fluctuating food grains production but it had never witnessed such a steep fall as in 2002-03 when the decline in food grains production is apprehended to be anywhere between 13-14 per cent. The development is attributed to the severest drought the country had to experience

in 2002-03. The month of July that normally records highest rainfall in monsoon in India, registered the lowest rainfall in the past 100 years. July normally receives about 30 per cent of the monsoon rainfall and the shortfall in 2002 was as high 49 per cent. Against 75.05 per cent of the total Full Reservoir Level (FRL) which is the average of last 10 years, country's reservoir storage at the end of the monsoon 2002 stood at 50.49 per cent. Rainfall during the 2002 monsoon season (June-September) was 19 percent below the normal rainfall having disastrous impact on different segments of the Indian economy, in irrigation and agriculture in particular. Drought condition reigned in 29 per cent of the country and it was severe in 10 percent area.

The gravity of the crisis that followed is reflected in the fact that country's food grains production has dropped 13.18 per cent in 2002-03. According to the federal Agriculture ministry, country's food grains production in 2002-03 is likely to be 184.06 million tonnes – a significant fall from 212.02 mn tonnes in 2001-02. This is lowest ever since 1996-97 when food grains production totaled 199.4 mn tonnes. While the Kharif production in 2002-03 is estimated at 89.45 mn tonnes, Rabi production is expected to be 94.61 mn tonnes.

Rice production in 2002-03 is estimated to be 17.40 percent lower at 76.91 mn tonnes than the previous year's 93.08 mn tonnes and wheat production declined by 2.15 percent at 70.26 mn tonnes compared with 71.81 mn tonnes in 2001-02.The maximum impact of drought is likely to be felt in the production of coarse cereals where the fall is estimated to be as steep as about 26 per cent at 25.1 mn tonnes compared with 33.9 mn beautiful tree, tonnes in 2001-02. Production of pulses too is likely to decrease by 10 percent at 11.8 mn tonnes in 2002-03.

Possibly the severest effect of drought would be felt in the oilseeds sector. Production is likely to nosedive about 24 percent - from 20.46 mn tonnes to 15.57 mn tonnes in 2001-02. Groundnut and soybean production are likely to decrease by 2.2 mn tones and 1.6 mn tonnes, respectively. Rapeseed/Mustard oilseeds production to fall by around 1 mn tonnes. Sugarcane production too is likely to witness lower production by about 5 per cent- at 285.4 mn tonnes. While cotton production has declined by 15.61 per cent, in respect of jute and Mesta the decline was between 5-6 per cent.

Innovation for Meeting World's Food Demand

Nearly 200 years ago, Thomas Robert Malthus observed a fundamental difference between human beings and the land: We increase; it does not. Malthus saw this as a harsh and inevitable natural limit to population growth. Increase in population density motivate farmers to use land more intensively, applying more human labour or labour-saving technology. Yields, the average amount of a crop produced per unit of land, have historically risen as a result.

1. From the 1960s to 1990, the Green Revolution tripled food production through the development of high-yield cereal grains, while the proportion of malnourished fell from 36 to 20 per cent of population in developing countries.

2. While the last 200 years have demonstrated the power of technological innovation, however, they have not resolved the question of long term resource constraints. Over the past three centuries, world population has increased eightfold while the amount of arable land has increased only fivefold. More intensive use of arable land has allowed food production to keep pace with population growth despite the slower expansion of arable land. There is limited potential, however, to expand arable land much further. Continued population growth could result in unsustainable demands on the earth's agricultural land and water resources in the coming decades.

The food security challenge that the development community has been grappling with over the last 50 years or so has become increasingly complex over time. In the 1940s and 1950s the challenge of improving global food security seemed a daunting, yet relatively straightforward task of increasing food production and increasing access to food predominantly for rural societies.

Generally a person needs more than 2400 cal/day nutrients. Many countries are suffering form less diet/person. Those countries where available food is less than 2100 cal/day are following:

Country	Available food cal/day/person
Mozambique	1805
Central African Republic	1846
Somalia	1874
Sierra	1899
Rwanda	1913
Haiti	2005
Bolivia	2013
Zambia	2016
Bangladesh	2037
Peru	2037
Sudan	2043
Malawi	2049
Kenya	2064

Those countries where available food is 2100-2400 cal/day are following:

Country	Available food cal/day/person
Zaire	2130
Ghana	2144
Medagascar	2156
Uganda	2178
Tanzania	2195
Nigeria	2200
Nepal	2205
Cameroon	2208
Honduras	2210
India	2229
Nigeria	2239
Guinea	2242
Srilanka	2246
Gwatemala	2254
Zimbawe	2256
Liberia	2259
Mali	2259
Botswana	2260
Panama	2269
Togo	2269
Pakistan	2280
Thialand	2280
Congo	2295
Senegal	2322
Philippines	2341
Mongolia	2361
Ecuador	2399

At the World Food Summit held in November, 1996 in Rome, political leaders gathered to consult on what the UN Food and Agriculture Organization (FAO) calls "the most basic problem of mankind: food insecurity." The leaders heard some disturbing statistics about expected growth in the world's population and its food needs:

The earth's population will rise by 1.5 per cent per year over the next decade. By 2010 it will swell to 7 billion.

By the year 2000, half the world will live in cities for the first time in history. That number is expected to rise to 75 per cent by 2030.

In 88 nations a large portion of the population suffers from deficient diets. Some 800 million people in all, including 200 million children, are chronically hungry.

Current grain stocks are at record lows, equivalent to just 48 days of world requirements.

Over the last half a century the world has changed dramatically and so has the food security challenge. Urbanization and Globalization are becoming pervasive, private sector involvement in agricultural research has been increasing at a very rapid pace around the world, and Global concerns about the sustainable management of resources have been rising. The global food security challenge has over time become increasingly complex as well as more multi-dimensional.

According to Von Prabhu Pingali world have to face 5 challenges for food productions. These chalanges are following:

1. Provisioning the urban masses especially the urban poor with adequate amounts of food and nutrition;
2. Eliminating rural poverty and attacking the problem of chronic food insecurity;
3. Repositioning developing country agriculture in the context of globalization;
4. Dealing with rising transactions costs of technology access and technology use;
5. Sustainably managing the natural resource base.

Provisioning the Urban Masses

Over the past 50 years the world has changed dramatically from one that was predominantly a rural based world to one where almost half the population is living in urban areas. Today approximately 3 billion people live in urban areas. The UN projections show that by the year 2030 5 billion people will be living in urban areas as opposed to roughly 3 billion in rural areas (UN 2000). In 1950 New York City was the only city with a population greater that 10 million people. By 2000 there were 19 cities with population greater than 10 million people, and by 2015 the projections are that there will be 23 mega-cities around the world (UN 2000). At the same time, there are thousands and thousands of villages that are turning into towns, there are thousands of towns that are turning into cities and there are thousands of cities that are turning into cities of a million people and more. Providing food to these exploding urban population will pose a dual challenge:

- Increasing the middle class rapidly in urban population
- Increasing poor and poorest class rapidly having income less than 1 dollar.

Policy agenda for provisioning the urban masses is the first issue on the agenda will be to appropriately balance trade and domestic production for meeting the food needs of the urban populations. Second, much of the food policy discussion and policy making in the developing world is centered on increasing cereal crop productivity in predominantly subsistence production systems.

Persistence of Poverty

The second area of urgent policy concern is the persistence of poverty is another important policy concern area, especially rural poverty. According the report of world bank issued in 2000, the numbers are very clear on the magnitude of the problem: about 1.2 billion people live on less than a dollar a day, 2.8 billion live on less that 2 dollars a day. Hazell and Haddad reported in 2001 that 44% of the world's poorest of the poor (those under a dollar a day) live in Sub-Saharan Africa and 40% live in South Asia. Although a lot of work was done in reducing poverty in East Asia, Southeast Asia and in Latin America over the last three decades, but the recent financial crisis in East Asia and Latin America and the slow down in economies. For reducing poverty following efforts can be done:

High levels of investments in education and infrastructure improvements targeted towards marginalized people will go a long way to integrate them into the market.

To reduce transaction costs in accessing markets for these households.

The third area of targeted policy interventions for marginalized people is to assess the role of research and technology development specifically for the less favourable environments. Development of drought tolerant crops, high temperature tolerant crops, etc. Attention ought to be paid to assessing the technical feasibility and economic viability of nutrient enhanced grain, with particular emphasis on Vitamin A rice, and Quality Protein Maize.

Development of varieties of crops resistant to various diseases. Some important crops developed in India are following:

Table 3.2

S.No.	Crop	Crop diseases	Resistant Varieties	Crop growing area
1	Wheat	Brown rust of Wheat *Puccinia triticina*	NP-783 NP-	Uttar Pradesh,
		Yellow rust of wheat *Puccinia glumarum*	784	Madhya Pradesh
		Black rust of Wheat *Puccinia graminis tritici*	NP-785	Himachal Pradesh
		All rusts of wheat	NP-786	-
		Loose smut	NP-789	-
		Pathogen *Ustilago nuda*	NP-790 -	Hills of H.P. and
			NP-809 -	U.P.
			NP-710	Punjab, H.P.
			NP-718	Rajasthan, Bihar,
				Bengal

contd...

2	Sugarcane	Red rot *Colletotrichum Fulcatum*	CO 419 CO 421 CO 356 CO 393 CO453 CO 508 COS 109	In all sugarcane growing areas
3	Rice	Blast of rice *Piricularia Oryzae*	CO25, CO 26, CO 24, T-141	Tamil Nadu
4	Cotton	Wilt of cotton *Fusarium, vas infactum*	Suyog, Vijay, Kalyan, H-420, Virnar	Gujarat, Maharashtra
5	Gram	Wilt of gram *Fusarium Orthoceros*	G-17, G-24	Uttar Pradesh
6	Ground nut	Tikka of ground nut- *Cercospora Personata*	Kanpur-23, M-20/38, AH-45	Kanpur, Tamul Nadu
7	Linum	Rust of Linseed *Melampsora Lini*	RR-10, RR-40, RR-45, RR-197, RR-236	Various states
8	Chilly	Mosaic of chilly	Puri red, puri orange	Delhi
9	Banana	Wilt of Banana *Fusarium Oxysporum Vas Infectum*	Busrai	Maharashtra
10	Coffee	Leaf diseases	Kent hybrid	South India
11	Lathyru	Wilt	Indore T-12	Madhya Pradesh
12	Ladies' s Finger	Various mosaic	Safal pusa sawani	All states

Repositioning Developing Country's Agriculture In the Context of Globalization

Globalization means different things to different people, so the best place to start is to state what it means to me. Globalization is associated with the integration of markets - capital, financial goods, services, and labour markets around the world. Globalization implies a unifying economic philosophy across the world. Integration of developing country's economies into the global system, especially for agriculture, leads to changing terms of trade and competitiveness of domestic food grain production. The policy agenda for developing countries facing a global food market may be following:

The first issue is how do developing countries empower themselves, through improved knowledge, to enable them to negotiate towards an agreement that minimizes the social adjustment costs, particularly for the poorest of the poor in their countries.

The second issue, which one can do something about through domestic policy change, is how to enhance competitiveness in areas where competitiveness has eroded. One way is through technological change and through institutional change.

The third agenda item is the role of the state in reducing the adjustment cost of people that are displaced from the market, especially those from the less competitive sectors.

Reducing the Transactions Costs in Technology Access and Use

Transactions costs in technology access and use are being increasingly recognized today due to the increased importance of biotechnology and multi-national private sector investments in agricultural research. Even as we discuss the problems of accessing modern biotechnology for the poor, we ought to recognize the fact that poor and marginal farmers have not been very successful in accessing the technology that is already on the shelf today. The policy agenda for reducing the transactions costs in technology access and use is following:

The first item on the agenda is to characterize the pro-poor potential of biotechnology innovations and investments.

The second agenda item is to identify the modus operendi for the creation of public/ private sector partnerships.

Finally, identifying small farmer constraints to technology access and use continues to be an issue that the development community ought to deal with.

Managing the Natural Resource Base

There are numerous concerns about the management and degradation of natural resources. These are following:

1. Degradation of intensively cultivated lands;
2. Exploitation and erosion of marginal lands;
3. Water resource depletion;
4. Depletion of genetic diversity
5. Government efforts for increasing productions;
6. Undertake meaningful official review of the agreement on Agriculture;
7. Support the creation of a development box.
8. Improve Market access;
9. Eliminate exports subsidies, export Guarantee and Insurance Programmes;
10. Reform the marrakech decision;
11. Promote sustainable agriculture;
12. Address anti-dumping and corporate concentration.

Exclude agricultural resources from patentability within the Trade Related Intellectual Property Rights Agreement (TRIPs).

Focus on existing WTO issues for developing and least developed countries

capacity building.

Innovations for Rising Food Productions

Overall, world food production has grown dramatically since the Green Revolution of the 1960s and 1970s. With the exception of a number of developing nations that have experienced production declines, the new crops and technologies of the Green Revolution boosted agricultural production at a rate faster than the growth in population. However, the rate of the increase in productivity has begun to slow down. The annual rise in production per person from 1970 to 1990 was 0.54 per cent. It is expected to be just 0.25 percent from 1990 to 2010. Why is production slowing down? When a new technology such as a hybrid crop, a pesticide, or a combine harvester is used, production rises. However, once the new technology is used by everyone, the rate of increase in production levels off. For example, as farmers switch from a standard grain variety to a high yielding hybrid, yields increase. But once every farmer uses the new variety, the maximum yield potential is soon achieved. Simply put, the technologies of the Green Revolution have achieved their desired results and they can no longer be expected to deliver large yield increases.

Most experts agree that the challenges of feeding an exploding population cannot be met simply by increasing production. Social and economic changes will be an essential part of a solution. Nevertheless - with 800 million currently undernourished and an additional billion mouths to feed by the year 2010 - vastly increased productivity will have to accompany any social and economic innovations. A second Green Revolution is needed. However, the next agricultural revolution will have to be substantially different than the first. The first Green Revolution involved high yielding plant varieties and more fuel, fertilizers, and pesticides. These technologies affected the environment by depleting non-renewable resources and producing pollutants. The FAO believes that the second Green Revolution will have to be more environmentally friendly. It will boost yields by improving genetic material and farm management without using excessive amounts of chemical fertilizers or pesticides. The FAO anticipate that one of the key components of this "greener" revolution will be agricultural biotechnology.

Biotechnology: A Key to Increased Food Production

Agricultural biotechnology makes use of the vast potential of genes to improve the performance of microbes, plants, and animals. Genes provide living organisms with a kind of blueprint for inherited traits. Using biotechnologies such as genetic engineering it is possible to change the genetic structure of living things, resulting in improved inherited traits.

A recent example of the potential of biotechnology to improve food production was discovered at the Plant Biotechnology Institute in Saskatoon. Late last year, researchers announced that they had discovered a genetic modification capable of increasing the oil production of rapeseed by up to 25 per cent! The research team believes that the same technology is applicable to canola, one of the world's major sources of food oil. They also expect that the technology can be applied to other oilseeds such as flax, corn, or soybeans.

Biotechnologies to Improve Plant Productivity

Genetic modification of crop plants to increase yield is just one of the plant biotechnologies being developed. Others include:

Biofertilizers

Using microbes, scientists have found methods to improve the way plants use food from the soil. These microbes can make crops more productive, and are more environmentally friendly than chemical fertilizers. An example of a biofertilizer is Provide, developed by the Saskatoon company Philom Bios. Provide produces an organic acid which dissolves the phosphate in the soil, making it available to plant roots.

Natural Insecticides

Certain naturally occurring chemicals in bacteria are toxic to insect pests that damage plants and reduce yield. Scientists can transfer genes for these proteins and chemicals from bacteria to crop plants. This will help protect the plants from pests and reduce dependence on insecticides. Already, the bacterium Bt has been bred into a wide variety of commercial crops.

Biotechnologies to Improve Livestock Productivity

Growth Hormones

The genetically modified bovine hormone bST can raise milk production in cows by 10 to 15 per cent. Researchers are also looking at a whole spectrum of genes that affect growth and production within the animal.

Feeding Improvements

Improved growth and production can also be achieved through more efficient conversion of animal feed into nutrients. This can be done both prior to feeding and inside the animal, by adding enzymes and microorganisms to stimulate better digestion.

Animal Health

Biotechnology has provided the means to produce large quantities of inexpensive animal vaccines. A vaccine against shipping fever, for example, will increase animal productivity by controlling a disease which costs producers $1 billion each year.

Aquaculture

Aquaculture, or fish farming, is the fastest growing food subsector in the world. Biotechnology is being used to improve production on several fronts, including nutrition, health, and growth promotion. Together, these and other biotechnologies will make a major contribution to meeting the food demands of an exploding world population.

The Green Revolution's success in fending off starvation even as Asia and Latin America's population doubled, from less than 2 billion to nearly 4 billion people, was a remarkable feat. Millions of human beings would not be able to survive today without the key innovations that launched the revolution. Foremost among these were advanced techniques of cross breeding that allowed development of rice, wheat and corn strains with increasingly higher yields per hectare. With sufficient access to irrigation water, fertilizers and pest controls, farmers could gain higher yields and, often, multiple crops in the same year, all with less labour.

Plant Used as Avenue Trees

Plants are grown in different areas from ancient times for shade and aesthetic values. Plants provides following objects:

(1) Maintain fertility of soil

(2) Prevent water loss.

(3) Provide shade to travelers.

(4) Improve ecology.

(5) Maintain ecological balance.

(6) Food, fodder provided.

(7) Provided scented smell and beauty.

Important plants related with avenue, shade and pollution control are following: —

Table 3.3

S. No.	Family	Botanical name	Flower colour	Time of flowering	Description
1	Apocynaceae	*Plumeria acutifolia* (chameli)	White	March April and July to October	A small tree 10-12 feet high, naked stem, slanting branches with broad, spear shaped leaf bunches and groups of sweet smelling fruits. Native tree of Mexico and Guatemala.
2	Apocynaceae	*Plumeria Rubra* (Red Champa)	Red	March April and July to October	Red colour flowers
3	Apocynaceae	*Plumeria Alba*	White	March April and July to October	A dwarf tree, branches have dark coloured leaf bunches, biggest tree of Champa tribe, generally evergreen tree, native tree of India, can be seen on the stone statues of Kushan period.
4	Apocynaceae	*Righkia Hictoria* (Dudhi)	Red	May	A small tree, white trunk like an elephant tooth, flowering in May, the entire tree is filled up with the red flower, which, appear very attractive.
5	Bignoniaceae	*Bignonia Crispa* (Padiri)	White	May-June	A very beautiful tree branches hang downwards, soft and shiny leaves, scented flower.
6	Bignoniaceae	*Jacaranda Folia* (Blue Gulmohar)	Purple-blue	March-April	A very beautiful tree, 15-30 feet high fern likes bipinnate leaves and a pyramid shaped bunch of blue flower has 40-100 blue flowers Native of Brazil.
7	Bignoniaceae	*Tikomella Undulata* or *Ticoma Undulata* (Rugotrora Rohertia)	Orange yellow	March-April	A small tree, wavy edged dull green leaves, flower in bunches on tips of smallest branches, orange-yellow flower, 5-10 flowered bunch, fully blooming, flowers appear very beautiful.
8	Bignoniaceae	*Mellingtoni ahortensis* (Skynveem,neem Chameli)	Silver white	April-June and November December	A high, straight growing very beautiful tree flowers have sweet smell.

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9	Bignoniaceae	*Cordia Sebasiina* (Red soda)	Orange red or deep red	January-March or whole year	A small dense dwarf tree, generally not more than 5 feet wrinkled leaves, bunches of orange red flower at the end of branches. It has been brought in India from Cuba and Tropical America.
10	Viccaceae	*Coclosper-mum Gossypium* (Guloc, Gugul)	Dark yellow	February-March	A small tree, 8-18 feet high, after complete leaf fall, golden yellow flowering occurs.
11	Combrtaceae	*Terminalia Arjuna* (Arjuna)	Cream like colour	March-June	Evergreen tall tree, smooth bark brown coloured, rectangular leaves in opposite arrangement and cupshaped flowers resembling flowers of harra.
12	Capparidceae	*Crativa Religiosa* or *Crativa nunwala* (Varna)	White	April	10-12 feet high small tree, zigzag branches, full of yellow flowers in the last week of April. Flowering starts after complete leaf fall very beautiful trees, suitable for being planted in the triangular junctions of roads.
13	Lythraceae	*Lagerstro-mia* Sp. (Arjun)	Blue violet or blue	April- May July- August	Small sized, evergreen tree, smooth, green brown bark, humid regions have taller trees.
14	Lythraceae	*Lagerstro-mia Thoralii* (Bigger sawani)	White and bright violet	July-September	Dwarf plant, shining violet spotted flowers.
15	Leguminosae	*Buteg Frondosa* (Ppiliona-ceae) or *Butes Monosper-ma* (Dhak or Plash)	Red orange	February-March	Generally a forest tree grows in barren land flowering occurs after the leaf fall in March-February. Entire tree is covered with red-orange flowers, which have red stamens. Yellow flowered varieties are also found.
16	Caesalpiniaid eae	*Bauhinia Purpurea* (Pink Katchnar)	Pink	Novem-ber	Medium sized evergreen tree, very beautiful. It needs popularity. The only drawback is that buds dry up very soon.
17	Caesalpiniaid eae	*Bauhinia Tomentosa* (Katchnar)	Light yellow	July-August	Evergreen tree which has light yellow coloured flowers in excess, in rainy season.

contd...

18	Caesalpinioid eae	*Bauhinia Triandra* (Red Katchnar)	Pink	October and Novem-ber	A small tree with light pink flower.
19	Caesalpinioid eae	*Bauhinia Variegata* (Katchnar baisakhi)	Pink White and red	February-March	Flowers light yellow spotted or red spotted pink or purple coloured, which flower after leaf fall.
20	Caesalpinioid eae	*Bauhinia Acuminata* (White Katchnar)	White	Whole year	About 10 feet high one small tree, white flowers for the whole year.
21	Caesalpinioi-deae	*Bauhinia Coimbosa* (White Katchnar)	Pink White	April	Small leafy climbers.
22	Caesalpinioid eae	*Bauhinia Alonia* (White Katchnar)	White red	April	Round, umbrella shaped dwarf tree.
23	Caesalpinioi-deae	*Cassia Fistula* (Amaltash)	Yellow	April-May	A small tree, leaf fall in March. Shining yellow flower bunches in April-May. New leaves are Copper like red coloured.
24	Caesalpinioi-deae	*Cassia Javonica* (Java queen)	Pink	May- June	Native of Malaya island. It has bunches of pink flower.
25	Caesalpinioi-deae	*Saraca Indica* (Sita ashoka)	Orange red	February-March	Heavily branching tree, flower in dense large sized bunches, orange at the time of blooming but become red afterwards, which appears very beautiful between green leaves. Hindus treat it as a very pious and dedicated to Kamdev.
26	Caesalpinioid eae	*Poenpiana Rosea* or *Delonix Rosea* (Gulmohar	Orange red	April -June	Umbrella-like tree pinnate leaves, leaf fall in March. It appears as a heap of red flower in April Native of Gasker island.
27	Caesalpinioi-deae	*Pointiana-Elata* (Gulmohar or Sankeshar)	Yellow white	February-March	A small dwarf tree looks like an open umbrella full of yellow white flowers in February- March, which appear very beautiful among green leaves. Found in excess in Madhya Pradesh.It has been migrated and grown in India from

contd...

28	Legminosae or Papilionaceae	*Erythrina Indica* (Indian coral tree)	Red	February-March	A small fast growing tree, leaves arranged in odd pattern. Red flowers bunch at the apex of last smaller branches.
29	Papilionaceae	*Glyrecidia Maculata* (spotted glyricidia-moderate tree)	Light pink	February-March	A small fast growing tree, long pinnate leaves fall in February, and then height pink flowering occurs. Its native country is Tropical America.
30	Papilionaceae	*Millettia Ovalifolia* (Malmean rosewood)	Blue	March	A small tree, blue coloured flowering occurs after leaf fall and cover the whole tree. Flower bunches hang downward giving a very attractive look.
31	Papilionaceae	*Entrolli-vium Saman* (Rain tree)	Light pink	March to September	A big tree, fast growing pinnate leaves, bunches of light pink.
32	Papilionaceae	*Peltoforum feruginium* or peltoforum	Shining yellow	March to May and Septem-ber to Novem-ber	A tall tree, 40 to 80 feet high, pinnate leaves; leaf fall in Jan. Tree is covered up with yellow flowers in February before the new leaves sprout. Tree flowers twice in a year. Native of Lanka.
33	Papilionaceae	*Pongamic Glabra* (Karanj)	Blue-Violet	April-May	A dwarf deciduous tree, trifoliar like Shisham, leaf fall in the end of April then it is covered with flowers and give a beautiful look. Shade is very good. Perfect for being planted in Railway stations.
34	Papilionaceae	*Pterocarpus Indicum* (Padak)	Golden yellow	May to July	40 to 50 feet high tree orange-yellow flowers bunch. Flowers wither very early.
35	Papilionaceae	*Sesbania Grandiflolia* (August)	Crea-my or pinkish	December	Fast growing small tree, two types of pinnate leaves, orange-pink flowered leaves and very light creamy or yellow coloured solitary flowered leaves, flowers can be fried into pakori. Pods are long and ugly, so they should be plucked from time to time.

contd...

36	Papilionaceae	*Thespesia Populinia* (Mendi peepal)	Yellow and red	Whole year	A big evergreen tree, shining dark green popular tree like leaves, flowering for the whole year, 30-40 feet high. Very capable of bearing the weight.
37	Malvaceae	*Kydia Calycina* (Barag, choupulatia)	Avua	September October	A small tree, beetle a shaped irregular big leaf bunches of white and pink flowers.
38	Malvaceae	*Hisbiscus Colinis*	Pink red flowers and black-purple coloured	November-December	Scattered branched small tree, beetle shaped three pointed tip leaves.
39	Malvaceae	*Coasia Speciosa* (Cotton tree)	Light yellow	October	A beautiful tree, bottle shaped green stem, after the leaf fall in October, yellow coloured flowering. Generally planted in Lucknow and Dehradun.
40	Moraceae	*Ficus Banghalensis* (Banyan)	Pulpy fruits hide the flowers fruits in the pairs of two		A huge tree, perfect for giving shadow. Hindus worship this tree.
41	Moringaceae	*Moringa Olifera* or *Moringa Pteregos-perma* (Sajjana)	Creamy white.	February to April	A beautiful tree, leaves multifoliate shaped, flowers in large bunches pods are edible, oil and fibers are also obtained.
42	Rubiaceae	*Mussaenda Glabrata* or *Mussaenda frondosa* (Lankut, Sarwat)	Orange	July to October	A straight growing tree or climber tree, branches are red. It is of medicinal value.

contd...

43	Sapotaceae	*Madhuca Latifolia* or *Bassia Latifolia* (Mahua)	Stamens are red like plums and petals are creamy white.	Feb to April	Very important Indian forest tree, fruits and flowers are nutritious. A deciduous tree, flowers bloom in the night and fall in the morning, various parts of this tree are utilized in different ways.
44	Solanaceae	Solanum sp.	Blue	Whole year	A 39 to 40 feet high tree. Leaves are 10-15 feet long. Grown in gardens for big leaves and beautiful flowers.
45	Sterculiaceae	*Sterculia Foetida* (Wild almond)	Deep red	February to March.	It is a straight growing tree. Branches spread all round in straight fashion.
46	Zygophyllaceae	*Guaiacum officinalis* (Tree of Life)	Shining blue	March and November	A shrubby tree, small deep green leaves. Blue coloured flower bunches mostly in March and November.

Plants for Pollution Control

For pollution control plants are grown in industrial areas. These are grown around industrial areas. These are planted in following way:

1. Zone I (Outer zone): It includes the zone where pollutants settled at tall trees. Here deciduous or evergreen tall plants are grown. Like: *Gravilea robusta, Casurina, Ficus religiosa,* and *Eucalyptus.* Scavenger sp. Like: *Azadirachta indica, Accacia sp.* also grown.

2. Zone II (Middle zone): It is wider zone where industries releases gases like:— Carbon dioxide, Ammonia. So here tolerant scavengers trees are grown Like: *Anthocephalous Cadamba, Ficus Sp., Dalbergia Sissoo, Azadirachta Indica, Cassia simea,* and sensitive sp. *Bauhinia Varigata, Albega Lebek, Ccllistemon* also grown.

3. Zone III (Host zone) : It is near to industrial unit. It causes many problems like leakage of gases, smoke and chemical products. Here pollution tolerant sp. are grown like *Syzygium Cumini, Ficus* Sp., *Dalbergia Sissoo, Petaphorum* Sp., *Accacia* Sp.

Principles of Conservation

Conservation in its broadest sense means to stop the unplanned development that breaks ecological as well as human laws by careless use of natural resources. 'Conservation' term technically denotes policies and programmes for the long-term retention of natural communities under condition, which provide the potential for continuing evolution.

Conservation of plants is important to maintain the existence of life on the earth. Various methods have been adopted to conserve, our forest wealth WWF along with many other organizations is taking several measures to wisely use the natural resources. IUCN has fostered a programme for the preparation and publication of 'Red data book' to draw attention towards endangered species. Conservation of plants is needed in relation to the needs of agriculture, medicine and industry.

Conservation is the most efficient and most beneficial utilization of natural resources and it is mainly conserved with the management of the natural resources of the earth, taking into consideration their proper use, preservation and protection from destructive influences and misuse etc. Hence, conservation may also be defined as the national use of the environment to provide a high quality of living for the mankind. Three main objectives of conservation:

(1) To ensure the preservation of a quality environment that considers aesthetic and recreational as well as product needs.

(2) To preserve biological diversity: Both genetic as well as ecological diversity are included in biological diversity.

(3) To ensure a sustainable utilization of species and ecosystem.

Conservation is very important for the social and economic development of a country. A well-managed and properly stocked forest reduces soil erosion and also mitigates floods which can otherwise do cause a great damage to agricultural land in lower regions.

Extinction

The process through which species are disappearing from nature is known as Extinction. It is expected that one species per day is going to extinct.

Mechanism of extinction: In any ecosystem, stability is indicated by higher biodiversity, because species show positive interactions. But these species are also having one important character, which is interlinking character. It means species are strongly correlated with each other. It is this condition, due to any change in the climate or attack of disease, any sensitive species disappears from nature, then its extinction will affect other species also, and other species, which are dependent on these species, will become weak and in that case, a chain reaction started in the ecosystem, which will indicate the retrogression of the ecosystem. With disappearance of one species, the nature of soil and climate are also affected and it will increase up the rate of extinction for maintaining the record of threatened and extinct species, "RED DATA BOOK" is published by IUCN.

Factors Affecting Rate of Extinction

The main causes for the extinction of species are as follows:

(1) **Overpopulation:** It is the fact that it population is high, then we need more resources and it will affect the ecosystem.

(2) **Over exploitation:** Nature is providing us sufficient amount of resources, but for maintaining the exploiting the nature, which is resulting in the form of change in climate.

(3) **Pollution:** It is again the result of luxurious life style, because irregular expansion of cities and industries are rapidly increasing the amount of pollutants in the environment, which are destroying the species.

(4) **Unavailability of alternative source:** Actually, the tribal and villagers are using natural resources, because they are not having alternative source, likes they are cutting forest because it is their employment. They are using the wood as a fuel.

(5) **Lack of awareness:** It is the May or threat. Actually, we don't know that what are we getting and what are we losing. That's why unknowingly; we are destroying the nature.

(6) **Selfishness:** It is the fact that human being is the selfish rase, and he is framing the rule in the favour of them. In that case, we avoid the nature, and it is creating the problem.

(7) **Natural phenomenon:** Many natural processes like earthquakes, volcanoes etc. are responsible for the destruction of nature, but the natural processes are related with evolution and in that case, the rate of extinction will be very low.

(8) **Evolution and speciation:** It is the natural process of extinction of species, because as the new species evolve, older species gets extincted so, the succession pattern of ecosystem shows extinction.

(9) **Shifting cultivation.** Actually, if one agricultural area become sterile, then the forest land is used as an agricultural field, it is known as shifting cultivation. So, it can destroy the species.

(10) **Habitat destruction:** Many habitats are destroyed because we need the land for colonies, agriculture, dams, roads and railway lines. So, during the cutting (clearing) of forests, so many species gets extincted.

(11) **Competition and invasion:** —When new weed species enter the ecosystem, then it competes with the local species for resources and during this competition, new species invade the area while local species extinct away. Like, in India, the common roadside plant was *Cassia Tora*, but as the *Parthenium* entered in these areas it invaded the whole zone. It replaced the *Cassia Tora* and at present time, *Cassia Tora* is disappearing from all such areas.

Environmental Status of Plants Based on IUCN

Several plant and animal species have become extinct and lives of many hundreds are threatened. IUCN's threatened plants committee found that about 10% (20,000 to 30, 000) of the world's flowering plants are dangerously rare or under threat (Eckholm, 1980). Among forest tropical rain forests are the most threatened. The food and agricultural organization of the United Nation estimates that about 40% of the tropical forest of the world have already been destroyed and that virtually all the remaining forests would be finished by the end of the century. About 20,000 seed plant species of our planet are threatened. IUCN has classified the endangered species of the world into 4 categories: —

(1) Endangered (E)

(2) Vulnerable (V)

(3) Extinct (Ex)

(4) Rare (R)

The easiest and least expensive way of preserving plant gene resource is seed storage in liquid nitrogen. This can help to preserve a large number of genotypes. Important for the conservation of plants are factors affecting the viability of seeds. Biosphere reserves are also established for conserving the flora and fauna.

Conservation measures: —The conservation strategies include afforestation, pollution control, setting of national parks and sanctuaries, botanical garden and biosphere reserves etc. Conservation can be done in two main ways – one that produces immediate results, like artificial propagation of endangered plants including tissue culture techniques and maintaining them in botanical gardens and fields. An additional technique is cryopreservation maintaining germplasm banks for preserving seeds, spores, pollen etc.

Review Questions

1. What do you understand by Green Revolution?
2. What are the various economic benefits of Green Revolution?
3. Define the role of biotechnology in improving plant productivity.
4. How genetic modification is done in plants?
5. Define the principle of conservation?

CHAPTER 4

STRATEGIES FOR CONSERVATION-IN SITU CONSERVATION

LEARNING OBJECTIVES

- International Efforts
- Protected Areas in India

International Efforts

For the protection of environment and to connect it with education, many steps have been taken at international level. One step is to establish an organization UNESCO. Later national parks and sanctuaries have also been established and the world's first national park was Yellowstone National Park of U.S.A. After that, many countries adopted the same concept. At initial level, in-situ conservation principle was proposed and different organizations were established for proper conservation among which the main organizations are following-

UNEP (United Nations Environmental Program):

It is related with protection of environment. Actually, the main cause of extinction of species is the change in environment This agency is related with the survey of environment, and time-to-time, it publishes the reports on changes in environment.

BDPIS (Biodiversity Program and Implementation Strategies):

This agency is related with the survey of biodiversity at world level and in different countries, sanction the projects on biodiversity. On the basis of available database, this agency formulates the strategy for conservation and observes its implementation.

UNFAO (United Nations Food and Agricultural Organization):

This agency is mainly related with conservation of crops, and repairs the strategy for proper distribution at world level.

CBD (Centre for Biodiversity)

This organization mark the areas, which are biodiversity rich, and these centres, are named as hotspots.

CITES (Convention on International Trade in Endangered Species):

These organizations monitor the trade of endangered species and prohibit such trade by legal ways.

CCMS (Convention on Conservation of Migratory Species):

Basically, it is related with migratory species only.

MAB (Man and Biosphere):

This organization identifies the biodiversity rich areas, and provides the fund for its conservation, which are named as Biosphere Reserves.

IUCN (International Union for Conservation of Nature and Natural Resources):

This organization is related with conservation of natural resources. It is the organization that initiated the establishment of national parks and sanctuaries.

Establishment of gene banks, seed banks and cryobanks

These programs have been initiated for germplasm conservation, which are responsible for ex-situ conservation.

Indian Initiatives

At Indian level also, many conservation programs are going on. India is rich in biodiversity. Here, approx. 84 national parks and 462 sanctuaries have been established. 14 biosphere reserves and botanical gardens have also been established.

For ex-situ conservation, many organizations are working. These are following:

1. BSI (Botanical Survey of India)
2. ZSI (Zoological Survey of India)
3. Zoo authority of India

4. CSIR
5. IARI
6. ICAR
7. NBPGR
8. DBT

Beyond these organizations many non-governmental organizations are also working. The role of Sundarlal Bahuguna for protection Tehri-Garwal area was important. His movement Chipko Andolan was a successful step at that time.

Protected Areas in India

Sanctuaries, National Parks and Biosphere Reserves

In India in-situ conservation is done through establishing national parks, sanctuaries and biosphere reserves. Total numbers of national parks are 98. Important national parks are following:

1.	Namdhapa National Park	(Arunachal Pradesh)
2.	Manas National Park	(Guwahati-Assam)
3.	Orang National Park	(Tezpur-Assam)
4.	Kaziranga National Park	(East Of Guwahati-Assam)
5.	Nameri National Park	(Sonitpur District-Assam)
6.	Sunderban National Park	(Calcutta-West Bengal)
7.	Vansda National Park	(Valsad District-Gujarat)
8.	Gir National Park and Sanctuary	(Gujarat)
9.	Velvadar Blackbuck national Park	(Bhavnagar-Gujarat)
10.	Marine Sanctury & Marine National Park	(Jamnagar-Gujarat)
11.	Navegaon National Park	(Navegoan, Gondia-Maharashtra)
12.	Pench National Park	(Near Nagpur-Maharashtra)
13.	Panna National Park	(Madhya Pradesh)
14.	Bandhavgarh National Park	(Madhya Pradesh)
15.	Kanha	(Mandla-Madhya Pradesh)
16.	Madhav (Shivpuri) National Park	(Madhya Pradesh)

17.	Betla National Park	(Nearby Ranchi-Bihar)
18.	National Zoological Park	(Near Old Fort-Delhi)
19.	Sultanpur National Park	(Haryana)
20.	The Great Himalayan National Park	(Nearby Kullu-Himachal Pradesh)
21.	The Hemis Altitude National Park	(Near Leh, Ladakh Region-J&K)
22.	Kishtwar High Altitude National Park	(Jammu - J&K)
23.	Keoladeo Ghana or Bharatpur National Park	(Bharatpur-Rajasthan)
24.	Desert National Park	(Rajasthan)
25.	Ranthambore National Park	(Ranthambore-Rajasthan)
26.	Dudhwa National Park	(Indo-Nepal Border-Uttar Pradesh)
27.	Govind National Park	(Uttar Kashi-Uttaranchal)
28.	Rajaji National Park	(Haridwar Dehradun, Pauri-Uttaranchal)
29.	Corbett National Park	(Southwest of Nainital-Uttaranchal)
30.	Valley of Flowers National Park	(Uttaranchal)
31.	Nanda Devi National Park	(Chamoli-Uttaranchal)
32.	Mahavir Harina Vanasthali National Park	(Vanasthalipuram-Andhra Pradesh)
33.	Sri Venkateshwara National Park	(Andhra Pradesh)
34.	Nagarahole National Park	(Karnataka)
35.	Bannerghata National Park	(Karnataka)
36.	Silent Valley National Park	(Near Mannarkkad-Kerala)
37.	Kasubrahmananda Reddy National Park	Andhra Pradesh
38.	Mrugavani National Park	Andhra Pradesh
39.	Sirohi National Park	Manipur
40.	Marine National Park	Andaman and Nicobar
41.	Galathea National Park	Andaman and Nicobar
42.	Mahatma Gandhi Marine National Park	And a man and Nicobar
43.	Campbell Bay National Park	Andaman and Nicobar
44.	Middle button National Park	Andaman and Nicobar

45. South button National Park	Andaman and Nicobar
46. Saddle Peak National Park	Andaman and Nicobar
47. Mt. Harriet National Park	Andaman and Nicobar
48. Valmiki national park	Bihar
49. City Forest National Park	Jammu and Kashmir
50. Anshi National Park	Karnataka
51. Kudremukh National Park	Karnataka
52. Bandhavgarh National Park	Madhya Pradesh
53. Indrawati National Park	Madhya Pradesh
54. Fossil National Park	Madhya Pradesh
55. Kanger Valley National Park	Madhya Pradesh
56. Satpura National Park	Madhya Pradesh
57. Van vihar National Park	Madhya Pradesh
58. Balphagram National Park	Meghalaya
59. Blue Mountain National Park	Mizoram
60. Noingphi National Park	Nagaland
61. Pigolakha National Park	Sikkim
62. Guindy National Park	Tamil Nadu
63. Gangotri National Park	Uttar Pradesh
64. Singalila National Park	West Bengal
65. Buxa National Park	West Bengal
66. Gorumara National Park	West Bengal

In India number of sanctuaries are 456. Important sanctuaries are following (list is region wise):

EAST INDIA

1.	Pabha or Milroy Sanctuary	(Lakhimpur District - Assam)
2.	Dibru - Saikhowa Wildlife Sanctuary	(Assam)
3.	Laokhowa Wildlife Sanctuary	(Nagaon District - Assam)

4.	Pabitora Wildlife Sanctuary	(Morigaon District - Assam)
5.	Bura-Chapuri Wildlife Sanctuary	(Sonitpur District - Assam)
6.	Sonai Rupai Wildlife Sanctuary	(Sonitpur District - Assam)
7.	Keibul Lam Jeo National Park	(Near Imphal - Manipur)
8.	Satkosia Basipalli Sanctuary	Chilika Lake(South West of Puri - Orissa)
9.	Chandka Elephant Reserve	(Orissa)
10.	Ushakothi Sanctuary	(Sambalpur - Orissa)
11.	Nandan Kanan	(Chandaka Forest - Orissa)
12.	Bhitarkanika Sanctuary	(Kendrapa District - Orissa)
13.	Simplipal Tiger Reserve	(Mayurbhanj District - Orissa)
14.	Ambapani Sanctuary	(Bhawanipatna - Orissa)
15.	Belghar Sanctuary	(Orissa)
16.	Gahirmatha Turtle Sanctuary	(Orissa)
17.	Karlapat	(Bhawanipatna - Orissa)
18.	Lakhari Valley Sanctuary	(Ganjam - Orissa)
19.	Padmatala Sanctuary	(Phulabani - Orissa)
20.	Tikarapada	(Anjul District - Orissa)
21.	Orchid Sanctuary	(Gangtok - Sikkim)
22.	Jaldapara Wildlife Sanctuary	(Near Siliguri - West Bengal)

WEST INDIA

23.	Thol Wildlife Sanctury	(Mehsana District-Gujarat)
24.	Gir National Park and Sanctuary	(Gujarat)
25.	Porbandar Bird Sanctury	(Porbandar-Gujarat)
26.	Wild Ass Sanctuary	(Little Rann of Kachh-Gujarat)
27.	Ratanmahal and Jessore Sloth Bear Sanctuary	(Champaner-Gujarat)
28.	Nalsarovar Bird sanctuary	(Gujarat)
29.	Marine Sanctury and Marine National Park	(Jamnagar-Gujarat)
30.	Narayan Sarovar Chinkara Sanctury	(Gujarat)

31.	Shoolpaneshwar Wildlife Sanctury	(Vadodra-Gujarat)
32.	Yawal Sanctury	(Jalgaon District-Maharashtra)
33.	Tadoba National Park	(Near Chandrapur-Maharashtra)
34.	Kalasubai Harischandragad Wildlife Sanctury	(Ahmednagar District Maharashtra)
35.	The Sanjay Gandhi National Park	(Borivali, Mumbai-Maharashtra)
36.	Radhanagri-Dajipur	(Kolhapur District-Maharashtra)
37.	Karnala Bird Sanctuary	(Panvel Taluka Of Raigad District-Maharashtra)
38.	Anerdam Wildlife Sanctury	(Shirpur Tehsil Of Dhule District-Maharashtra)
39.	Bhamragarh Wildlife Sanctury	(Chandrapur District-Maharashtra)
40.	Bhimashankar Wildlife Sanctury	(Western Ghats Of Maharashtra)
41.	Bor Wildlife Sanctury	(Hingni in Wardha-Maharashtra)
42.	Chaprala Wildlife Sanctury	(Chandrapur District-Maharashtra)
43.	Chikhaladara Wildlife Sanctury	(Vidarbha Region-Maharashtra)
44.	Dajipur Bison Sanctury	(Border of Kolhapur District-Maharashtra)
45.	Gugamal National Park	(Amaravati District-Maharashtra)
46.	Jijamata Udyan Zoo	(Byculla District-Maharashtra)
47.	Jayakwadi Bird Sanctuary	(Aurangabad District-Maharashtra)
48.	Katepurna Sanctury	(Akola District-Maharashtra)
49.	Koyna Wildlife Sanctury	(Satara District-Maharashtra)
50.	Malvan Marine sanctuary	(Sindhudurg District-Maharashtra)
51.	Nagzira Wildlife Sanctury	(Tirora Range of Bhandara Forest-Maharashtra)
52.	Nandurmadhmeshwar Bird Sanctury	(Niphad Tehsil of Nashik District - Maharashtra)
53.	Nayagaon Mayur Sanctury	(Beed District-Maharashtra)
54.	Phansad Wildlife Sanctury	(Raigad District-Maharashtra)
55.	Peshwe Udyan	(Pune - Maharashtra)
56.	Sagareshwar Sanctury	(Khanapur Tehsil-Maharashtra)

57.	Tipeshwar Sanctury	(Yavatmal District-Maharashtra)
58.	Tansa Wildlife Sanctury	(Thane District-Maharashtra)
59.	Wan Sanctury	(Amaravati District-Maharashtra)
CENTRAL INDIA		
60.	Achanakmar Wildlife Sanctuary	(Madhya Pradesh)
61.	Bori Wildlife Sanctuary	(Hoshangabad District-Madhya Pradesh)
62.	Sanjay/Dubri Wildlife Sanctuary	(Madhya Pradesh)
63.	Sitanadi Wildlife Sanctuary	(Madhya Pradesh)
64.	Barnawapara Wildlife Sanctuary	(Madhya Pradesh)
NORTH INDIA		
65.	Palamau Tiger Reserve	(Nearby Daltonganj-Bihar)
66.	Hazaribagh Sanctuary	(Bihar)
67.	Maharana Pratap Sagar	(Himachal Pradesh)
68.	Pong Lake Sanctuary	(Kangra District-Himachal Pradesh)
69.	Pin Valley Park	(Lahaul Spiti District-Himachal Pradesh)
70.	Daranghati Sanctuary	(Rampur Bushahr, Shimla-Himachal Pradesh)
71.	Kalatop Wildlife Sanctuary	(Khajjiar, Chamba District-Himachal Pradesh)
72.	Kanwar Sanctuary	(Parbati Valley, Kullu-Himachal Pradesh)
73.	Bandli Sanctuary	(Mandi District-Himachal Pradesh)
74.	Simbalbara Sanctuary	(Paonta Valley, Sirmour District-Himachal Pradesh)
75.	Nature Parks	(Shimla District-Himachal Pradesh)
76.	Renuka Sanctuary	(Nahan, Sirmour District-Himachal Pradesh)
77.	Churdhar Sanctuary	(Solan Valley, Shimla-Himachal Pradesh)
78.	Chail Sanctuary	(Solan Valley, Shimla-Himachal Pradesh)
79.	Majathal Sanctuary	(Himachal Pradesh)
80.	Manali Sanctuary	(Kullu-Himachal Pradesh)
81.	Overa Wildlife Sanctuary	(Near Pahalgam, Kashmir-J&K)

82.	Dachigam	(Nearby Srinagar-J&K)
83.	Gulmarg Biosphere Reserve	(Southwest of Srinagar-J&K)
84.	Jasrota Wildlife Sanctuary	(Near by Jammu-J&K)
85.	Overa-Aru Biosphere Reserve	(Southest of Srinagar-J&K)
86.	Nandini Wildlife Sanctuary	(Nearby Jammu-J&K)
87.	RamNagar Wildlife Sanctuary	(Nearby Jammu-J&K)
88.	Surinsar Mansar Wildlife Sanctuary	(Nearby Jammu-J&K)
89.	Sariska Wildlife Sanctuary	(Rajasthan)
90.	Nawab Ganj Bird Sanctuary	(Nearby Lucknow-Uttar Pradesh)
100.	Askot Wildlife Sanctuary	(Pithoragarh-Uttaranchal)
101.	Hastinapur Sanctuary	(Meerut, Ghaziabad-Uttar Pradesh)
102.	Kedarnath Sanctuary	(Chamoli-Uttaranchal)
103.	Kishanpur Sanctuary	(Uttar Pradesh)
104.	National Chambal Sanctuary	(Etawah, Agra-Uttar Pradesh)
105.	Chandra Prabha Sanctuary	(Near Varanasi-Uttar Pradesh)
106.	Katrniaghat Sanctuary	(Near Indo-Nepal Border-Uttar Pradesh)
107.	Ranipur Sanctuary	(Uttar Pradesh)
108.	Kaimoor Wildlife Sanctuary	(Bihar Border-Uttar Pradesh)
109.	Mahavir Sanctuary	(Lalitpur-Uttar Pradesh)

SOUTH INDIA

110. Alisagar Deer Park	(Nizamabad District-Andhra Pradesh)
111. Sivaram Wildlife Sanctuary	(Adilabad District-Andhra Pradesh)
112. Pakhal Wildlife Sanctuary	(Near Warangal-Andhra Pradesh)
113. Pranahita Wildlife Sanctuary	(Chinnur, Adilabad District-Andhra Pradesh)
114. Eturnagaram Wildlife Sanctuary	(Near Warangal-Andhra Pradesh)
115. Kinnerasani Wildlife Sanctuary	(Khammam District-Andhra Pradesh)
116. Papikonda Wildlife Sanctuary	(Near Rajahmundry-Andhra Pradesh)
117. Pocharam Wildlife Sanctuary	(Medak District-Andhra Pradesh)
118. Gundlabrahmeshwaram Wildlife Sanctuary	(Andhra Pradesh)

119. Kawal Wildlife Sanctuary (Jannaram-Andhra Pradesh)

120. Srilanka Malleswara Wildlife Sanctuary (Near Cuddapah-Andhra Pradesh) 121. Kaundinya Wildlife Sanctuary(Near Chittor-Andhra Pradesh)

122. Kolleru Bird Sanctuaries (West Godavari District-Andhra Pradesh)

123. Nelaputta Bird Sanctuaries (Nellore District-Andhra Pradesh)

124. Manjira Bird Sanctuaries (Sangareddy,Medak District-Andhra Pradesh)

125. Rollapadu Bird Sanctuaries (Near Nandikotkuru-Andhra Pradesh)

126. Coringa Sanctuary (East Godavari District-Andhra Pradesh)

127. Pulicat Sanctuary (Nellore District-Andhra Pradesh)

128. Shamirpet Deer Park (Near Secunderabad-Andhra Pradesh)

129. Krishna Sanctuary (Near Avanigadda Village-Andhra Pradesh)

130. Nehru Zoological Park (Hyderabad-Andhra Pradesh)

131. Indira Gandhi Zoological Park (Vishakapatnam-Andhra Pradesh)

132. Srisailam Sanctuary (Near Nagarjunasagar-Andhra Pradesh)

133. Salim Ali Bird Sanctuary (North Goa)

134. Cotigoa Wildlife Sanctuary (Canacona District-Goa)

135. Bhagwan Mahavir Wildlife Sanctuary (Near Panaji-Goa)

136. Bondla Wildlife Sanctuary (Near Panjim-Goa)

137. Bheemeshwari Wildlife Sanctuary (Mandya District-Karnataka)

138. Bandipur Wildlife Sanctuary (Karnataka)

139. Bhadra Wildlife Sanctuary (Chikmaglur and Shimoga District-Karnataka)

140. Kabini Wildlife Sanctuary (Karapur-Karnataka)

141. B.R.Hills Wildlife Sanctuary (Kemmannagundi-Karnataka)

142. Dandeli Wildlife Sanctuary (Karwar-Karnataka)

143. Ranganathittu Bird Sanctuary (Mysore District-Karnataka)

144. Shendurni Wildlife Sanctaury (Near Kollam-Kerala)

145. Thattekad Bird Sanctuary (Near Kothamangalam-Kerala)

146. Aralam Wildlife Sanctuary (Near Thalassery-Kerala)
147. Eravikulam Wildlife Sanctuary (Near Munnar-Kerala)
148. Idukki Wildlife Sanctuary (Near Thodupuzha-Kerala)
149. Neyyar Wildlife Sanctuary (Southeast of Western Ghats-Kerala)
150. Parambikulam Wildlife Sanctuary (Near Palakkad-Kerala)
151. Peppara Wildlife Sanctuary (Near Thiruvananthapuram-Kerala)
152. Periyar Wildlife Sanctuary (Kerala)
153. Kadalundi Bird Sanctuary (Near Kozhikode-Kerala)
154. Chinnar Wildlife Sanctuary (Idukki - Kerala)
155. Kumarakom Bird Sanctuary (Near Kottayam-Kerala)
156. Rajamala Wildlife Santuary (Near Munnar-Kerala)
157. Wayanad Wildlife Sanctuary (Near Calicut-Kerala)
158. Peechi Vazhani Wildlife Sanctuary (Near Thrissur-Kerala)
159. Calimere Sanctuary (Southeast of Thanjavur-Tamil Nadu)
160. Mudumalai Wildlife Sanctuary (Near Udhagamandalam-Tamil Nadu)
161. Vedantangal Sanctuary (Kanchipuram District-Tamil Nadu)
162. Anamalai Sanctuary (Near Coimbatore -Tamil Nadu)
163. Kalakadu Wildlife Sanctuary (Tirunelveli District-Tamil Nadu)
164. Kunthakulam Bird Sanctuary (Nanguneri Taluk-Tamil Nadu)
165. Mundanthurai Wildlife Sanctuary (Tirunelveli District-Tamil Nadu)
166. Viralimalai Sanctuary (Near Tiruchirapalli-Tamil Nadu)

Beyond these other sanctuaries are following (List is state wise):

S. No.	Name of Sanctuary	State
167.	North Button	Andaman and Nicobar
168.	Great Nicobar Biosphere Reserve	Andaman and Nicobar
169.	Galthea Bay Sanctuary	Andaman and Nicobar
170.	Eagle Nest Wildlife Sanctuary	Arunachal Pradesh
171.	Itanagar Wildlife Sanctuary	Arunachal Pradesh
172.	Kane Wildlife Sanctuary	Arunachal pradesh

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173.	D'Ering Memorial Wildlife Sanctuary	Arunachal Pradesh
174.	Kamlang Wildlife Sanctuary	Arunachal Pradesh
175.	Mehao Wildlife Sanctuary	Arunachal Pradesh
176.	Barnadi Wildlife Sanctuary	Assam
177.	Kachugaon Game Reserve	Assam
178.	Deepan Beel Wildlife Sanctuary	Assam
179.	Parasnath Wildlife Sanctuary	Bihar
180.	Valmiki National Park	Bihar
181.	Gautam Buddha Wildlife Sanctuary	Bihar
182.	Kaimur Wildlife Sanctuary	Bihar
183.	Lawalong Wildlife Sanctuary	Bihar
184.	Nagi Dam Wildlife Sanctuary	Bihar
185.	Palkot Wildlife Sanctuary	Bihar
186.	Topchanchi Wildlife Sanctuary	Bihar
187.	Vikramshila Wildlife Sanctuary	Bihar
188.	Khabar Lake Wildlife Sanctuary	Bihar
189.	Bhimbandh Wildlife Sanctuary	Bihar
190.	Dalma Wildlife Sanctuary	Bihar
191.	Kodarma Wildlife Sanctuary	Bihar
192.	Mahaudaduar Wildlife Sanctuary	Bihar
193.	Nakti Dam Wildlife Sanctuary	Bihar
194.	Rajgir Wildlife Sanctuary	Bihar
195.	Udaipur Wildlife Sanctuary	Bihar
196.	Diu-Fudam Wildlife Sanctuary	Daman, diu, Nagar Haveli
197.	Asola Wildlife Sanctuary	Delhi
198.	Barda Wildlife Sanctuary	Gujarat
199.	Hingolgadh Mature Education Wildlife Sanctuary	Gujarat
200.	Pania Wildlife Sanctuary	Gujarat
201.	Dhumkhal Sloth Bear Wildlife Sanctuary	Gujarat

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202.	Gaga Great Indian Bustard Wildlife Sanctuary	Gujarat
203.	Khiadia Bird Sanctuary	Gujarat
204.	Jambugodha Wildlife Sanctuary	Gujarat
205.	Balram Ambaji Wildlife Sanctuary	Gujarat
206.	Purna Wildlife Sanctuary	Gujarat
207.	Rampura Vidi Wildlife Sanctuary	Gujarat
208.	Abubsahar Wildlife Sanctuary	Haryana
209.	Bir Bara Ban Wildlife Sanctuary	Haryana
210.	Chautala Wildlife Sanctuary	Haryana
211.	Kalesar Wildlife Sanctuary	Haryana
212.	Nahar Wildlife Sanctuary	Haryana
213.	Bhindwas Wildlife Sanctuary	Haryana
214.	Bir Shikargarh Wildlife Sanctuary	Haryana
215.	Chili Chila Wildlife Sanctuary	Haryana
216.	Khaparwas Wildlife Sanctuary	Haryana
217.	Saraswati Plantation Wildlife Sanctuary	Haryana
218.	Nargu Wildlife Sanctuary	Himachal Pradesh
219.	Lippa Asrang Wildlife Sanctuary	Himachal Pradesh
220.	Naina Devi Wildlife Sanctuary	Himachal Pradesh
221.	Kugati Wildlife Sanctuary	Himachal Pradesh
222.	Gamgul Siabehi Wildlife Sanctuary	Himachal Pradesh
223.	Kyas Wildlife Sanctuary	Himachal Pradesh
224.	Rupi Bhabha Wildlife Sanctuary	Himachal Pradesh
225.	Shimla Catchment Wildlife Sanctuary	Himachal Pradesh
226.	Tirthan Wildlife Sanctuary	Himachal Pradesh
227.	Shikari Devi Wildlife Sanctuary	Himachal Pradesh
228.	Sangla (Rakcham - Chitkul) Wildlife Sanctuary	Himachal Pradesh
229.	Shilli Wildlife Sanctuary	Himachal Pradesh
230.	Darlaghat Wildlife Sanctuary	Himachal Pradesh

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231.	Khokhan Wildlife Sanctuary	Himachal Pradesh
232.	Kibar Wildlife Sanctuary	Himachal Pradesh
233.	Sechu Tuan Nala Wildlife Sanctuary	Himachal Pradesh
234.	Talra Wildlife Sanctuary	Himachal Pradesh
235.	Tunda Wildlife Sanctuary	Himachal Pradesh
236.	Trikoot Wildlife Sanctuary	Jammu and Kashmir
237.	Baltal Thajwas Wildlife Sanctuary	Jammu and Kashmir
238.	Hirapore Wildlife Sanctuary	Jammu and Kashmir
239.	Lacchipora Wildlife Sanctuary	Jammu and Kashmir
240.	Changdhung Wildlife Sanctuary	Jammu and Kashmir
241.	Hokarsar Wildlife Sanctuary	Jammu and Kashmir
242.	Limber Wildlife Sanctuary	Jammu and Kashmir
243.	Shettihalli Wildlife Sanctuary	Karnataka
244.	Talakavari Wildlife Sanctuary	Karnataka
245.	Biligiri Wildlife Sanctuary	Karnataka
246.	Kaveri Wildlife Sanctuary	Karnataka
247.	Ghataprabha Wildlife Sanctuary	Karnataka
248.	Melkote Temple Wildlife Sanctuary	Karnataka
249.	Nugu Wildlife Sanctuary	Karnataka
250.	Ranebennur Wildlife Sanctuary	Karnataka
251.	Someshwar Wildlife Sanctuary	Karnataka
252.	Arabithittu Wildlife Sanctuary	Karnataka
253.	Brahmgiri Wildlife Sanctuary	Karnataka
254.	Doraji Bear Wildlife Sanctuary	Karnataka
255.	Gudavi Wildlife Sanctuary	Karnataka
256.	Mukambika Wildlife Sanctuary	Karnataka
257.	Puspagiri Wildlife Sanctuary	Karnataka
258.	Sharvathi Valley Wildlife Sanctuary	Karnataka
259.	Agastya Vanam Biological Park	Kerala

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260.	Chimmony Wildlife Sanctuary	Kerala
261.	Bagdara Wildlife Sanctuary	Madhya Pradesh
262.	Ghatigaon Wildlife Sanctuary	Madhya Pradesh
263.	Karera Wildlife Sanctuary	Madhya Pradesh
264.	Kheoni Wildlife Sanctuary	Madhya Pradesh
265.	Neoradehi Wildlife Sanctuary	Madhya Pradesh
266.	Palpur (Kuno) Wildlife Sanctuary	Madhya Pradesh
267.	Panpatha Wildlife Sanctuary	Madhya Pradesh
268.	Ralamandal Wildlife Sanctuary	Madhya Pradesh
269.	Sailana Wildlife Sanctuary	Madhya Pradesh
270.	Semarsot Wildlife Sanctuary	Madhya Pradesh
271.	Tamor Pingla Wildlife Sanctuary	Madhya Pradesh
272.	Badalkhal Wildlife Sanctuary	Madhya Pradesh
273.	Gandhi Sagar Wildlife Sanctuary	Madhya Pradesh
274.	Gomardha Wildlife Sanctuary	Madhya Pradesh
275.	Ken Ghariyal Wildlife Sanctuary	Madhya Pradesh
276.	Narsingarh Wildlife Sanctuary	Madhya Pradesh
277.	Pachmarhi Wildlife Sanctuary	Madhya Pradesh
278.	Pamed Wildlife Sanctuary	Madhya Pradesh
279.	Phena Wildlife Sanctuary	Madhya Pradesh
280.	Ratapani Wildlife Sanctuary	Madhya Pradesh
281.	Sardarpur Wildlife Sanctuary	Madhya Pradesh
282.	Singhori Wildlife Sanctuary	Madhya Pradesh
283.	Udanti (Wild Buffalo) Wildlife Sanctuary	Madhya Pradesh
284.	Melghat Tiger Reserve	Maharashtra
285.	Ambabarwa Wildlife Sanctuary	Maharashtra
286.	Andhari Wildlife Sanctuary	Maharashtra
287.	Chandoleł Wildlife Sanctuary	Maharashtra
288.	Dyanganga Wildlife Sanctuary	Maharashtra

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289.	Devalgaon Rahekuri, Wildlife Sanctuary	Maharashtra
290.	Gautala Wildlife Sanctuary	Maharashtra
291.	Painganga Wildlife Sanctuary	Maharashtra
292.	Yangupole - Lokchao Wildlife Sanctuary	Manipur
293.	Mawphlong Sacred Grove	Meghalaya
294.	Baghmara Wildlife Sanctuary	Meghalaya
295.	Nongkhijem Wildlife Sanctuary	Meghalaya
296.	Nokrek Biosphere Reserve	Meghalaya
297.	Sisu Wildlife Sanctuary	Meghalaya
298.	Nengpui Wildlife Sanctuary	Mizoram
299.	Nwanglung Wildlife Sanctuary	Mizoram
300.	Dampa Wildlife Sanctuary	Mizoram
301.	Mount Saramati Wildlife Sanctuary	Nagaland
302.	Phakim Wildlife Sanctuary	Nagaland
303.	Rangapahar Wildlife Sanctuary	Nagaland
304.	Pulebadze Wildlife Sanctuary	Nagaland
305.	Bhalukham Wildlife Sanctuary	Orissa
306.	Hadgarh Wildlife Sanctuary	Orissa
307.	Kotagarh Wildlife Sanctuary	Orissa
308.	Sunabeda Wildlife Sanctuary	Orissa
309.	Debrigarh Wildlife Sanctuary	Orissa
310.	Khalasuni Wildlife Sanctuary	Orissa
311.	Kuldiha Wildlife Sanctuary	Orissa
312.	Abohar Wildlife Sanctuary	Punjab
313.	Bir Gurdial Pura Wildlife Sanctuary	Punjab
314.	Takhani Rahampur Wildlife Sanctuary	Punjab
315.	Bir Bunrehari Wildlife Sanctuary	Punjab
316.	Bir Motibag Wildlife Sanctuary	Punjab
317.	Harike Lake Wildlife Sanctuary	Punjab

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318.	Gajner Wildlife Sanctuary	Rajasthan
319.	Kumbalgarh Wildlife Sanctuary	Rajasthan
320.	Sitamata Wildlife Sanctuary	Rajasthan
321.	Darah Wildlife Sanctuary	Rajasthan
322.	Jamwa-Ramgarh Wildlife Sanctuary	Rajasthan
323.	Ramgarh Vishdhari Wildlife Sanctuary	Rajasthan
324.	Jawahar Sagar Wildlife Sanctuary	Rajasthan
325.	Talchappar Wildlife Sanctuary	Rajasthan
326.	Chambal Wildlife Sanctuary	Rajasthan
327.	Jaisamand Wildlife Sanctuary	Rajasthan
328.	Mt. Abu Wildlife Sanctuary	Rajasthan
329.	Van Vihar Wildlife Sanctuary	Rajasthan
330.	Kancendzonga Biosphere Reserve	Sikkim
331.	Fambong Lho Wildlife Sanctuary	Sikkim
332.	Kyangnosla Alpine Sanctuary	Sikkim
333.	Pangolakha National Park	Sikkim
334.	Varsey Rhododendron Sanctuary	Sikkim
335.	Tendong Reserve Forest	Sikkim
336.	Maenam Wildlife Sanctuary	Sikkim
337.	Singhba Rhododendron Sanctuary	Sikkim
338.	Indira Gandhi Wildlife Sanctuary	Tamil Nadu
339.	Gulf of Mannar Biosphere Reserve	Tamil Nadu
340.	Mukurthi Nilgiri Tahr Wildlife Sanctuary	Tamil Nadu
341.	Karaikuli Wildlife Sanctuary	Tamil Nadu
342.	Guindy National Park, Chennai	Tamil Nadu
343.	Kothankulam Wildlife Sanctuary	Tamil Nadu
344.	Upper Kodyar Wildlife Sanctuary	Tamil Nadu
345.	Nilgiri Biosphere Reserve	Tamil Nadu
346.	Srivilliputhur Grizzled Squirrel	Tamil Nadu

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	Wildlife Sanctuary	
347.	Vettangudi Bird Sanctuary	Tamil Nadu
348.	Chitrangadi Wildlife Sanctuary	Tamil Nadu
349.	Kanjiramkulam Wildlife Sanctuary	Tamil Nadu
350.	Udnimarthamlapuram Wildlife Sanctuary	Tamil Nadu
351.	Vallandu Wildlife Sanctuary	Tamil Nadu
352.	Gumti Wildlife Sanctuary	Tripura
353.	Sipahijala Wildlife Sanctuary	Tripura
354.	Rowa Wildlife Sanctuary	Tripura
355.	Trishna Wildlife Sanctuary	Tripura
356.	Binsar Wildlife Sanctuary	Uttar Pradesh
357.	Mussoorie Wildlife Sanctuary	Uttar Pradesh
358.	Parvati Aranga Wildlife Sanctuary	Uttar Pradesh
359.	Saman Wildlife Sanctuary	Uttar Pradesh
360.	Sohagibarwa Wildlife Sanctuary	Uttar Pradesh
361.	Sonanadi Wildlife Sanctuary	Uttar Pradesh
362.	Surha Tal Wildlife Sanctuary	Uttar Pradesh
363.	Vijai Sagar Wildlife Sanctuary	Uttar Pradesh
364.	Bakhira Wildlife Sanctuary	Uttar Pradesh
365.	Lake Bahosi Wildlife Sanctuary	Uttar Pradesh
366.	Okhla Wildlife Sanctuary	Uttar Pradesh
367.	Patna Wildlife Sanctuary	Uttar Pradesh
368.	Sandi Wildlife Sanctuary	Uttar Pradesh
369.	Sohelwa Wildlife Sanctuary	Uttar Pradesh
370.	Sur Sarovar Wildlife Sanctuary	Uttar Pradesh
371.	Turtle Wildlife Sanctuary	Uttar Pradesh
372.	Mahananda Wildlife Sanctuary	West Bengal
373.	Ramnabagan Wildlife Sanctuary	West Bengal
374.	Bethuadahari Wildlife Sanctuary	West Bengal

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375.	Chapramari Wildlife Sanctuary	West Bengal
376.	Jore Pokhri Wildlife Sanctuary	West Bengal
377.	Raigunj Wildlife Sanctuary	West Bengal
378.	Ballabhpur Wildlife Sanctuary	West Bengal
379.	Bibhutibhushan Wildlife Sanctuary	West Bengal
380.	Narendrapur Wildlife Sanctuary	West Bengal

Wetlands

Any water body, which is natural or artificially constructed, is known as wetlands. Actually, wetlands are submerged and water saturated land area. It is submerged temporarily or permanently. Its water may be static or flowing, fresh or salty, so all the rivers, lakes, ponds and coastal areas of oceans are included in wetlands. In India, National wetlands management committee identified 16 wetlands, which are following:-

1. Kolleru ——Andhra Predesh
2. Wullar—— Jammu and Kashmir
3. Chilka—— Orissa
4. Loktak—— Manipur
5. Bhoj—— Madhya Pradesh
6. Sambhar—— Rajasthan
7. Pichola—— Rajasthan
8. Ashtamudi——Kerala
9. Sasthankota——Kerala
10. Harike—— Punjab
11. Kanjli—— Punjab
12. Vini—— Maharashtra
13. Sukhna—— Chandigarh
14. Renuka—— Himachal Predesh
15. Kaber lake—— Bihar
16. Nal Sarovar lake—— Gujarat

Chilka Lake

Chilka lake is the largest brackish water lake in India while Sambhar lake is the largest saline lake. For the management of wetlands, department of environment was set up in 1980. Lake Chilka has largely contributed to fishery. Mullets, perches, prawn, crab, oysters are the edible fauna. It is related with planning, promotion and co-ordination of wetland

program. Similarly, CPCB (Central pollution control board) is also related with assessment of water of wetlands.

After 1985, NWDB prepared the afforestation programs and wetlands have been regenerated. It is trying to recover the wetlands through forestry programs.

Mangroves

Mangroves are the precious vegetation because these are terrestrial plants adopted in salty water. These plants are euhalophytes, so these are having the genes for adapting in salinity. Mangroves are present in selected areas only, like in India, either they are present in Sunderbans (West Bengal) or in Andaman and Nicobar. The conservation of these plants is carried out in-situ conservation. These areas are completely protected as National parks. Sunderbans is the important National park of West Bengal. Similarly, Andaman and Nicobar islands have also been protected. For the Marine and coastal bio resources management, department of biotechnology launched a program. This program is initiated in the guidance of National Bioresource Development Board. This board publishes regularly the status of available resources, and in the selected areas, the genetic diversity is studied with the molecular marker system. With the help of molecular markers, 28 mangrove species were identified in Bhitara-Kanika Mangrove forest. Species-specific genetic finger printing was observed. The main species are -*Nicennia Marina, Rhizophora Mucornata* and *Xylocarpus Granatum* are studied, which is helpful for germplasm conservation and with the help of this study, degraded mangrove locations have been restored. For the different mangrove species, DNA library was constructed , because it provides the genetic material for abiotic stress resistance. The sequence of different genes had been determined and its cloning was carried out. The relationship of these genes is found out with other genes too.

Coral Reefs

Coral reefs are main characteristics of tropical oceans. These are the products of coelenterate animals. These coelenterates, which have sedentary nature, are known as polyps. These polyps continuously secrete calcium carbonate, and after death, these are deposited and form the rocks. These rocks are known as coral reefs, and the animals are known as corals. In nature, coral reefs are of 3 types:

Fringing coral reef:	This reef is present at coastal areas, and between island and reef, lagoon is present. Lagoon is shallow and its width is 20-40 m.
Barrier reef:	It is similar to fringing reef, but lagoon is much more wide.
Atoll reef:	It is horseshoe shape islands, and the lagoon is broad.

Important fringing reefs are found in:

1. Mandapam
2. Appa islands
3. Hare islands

While, the largest reef is, Great Barrier reef of Australia. Many islands, like – Gulf of Mannar, Krusadi islands, Lakshadweep islands are coral reef islands. In the coral reefs, different types of animals live, so its conservation is important. For the conservation of coral reefs, national fish and wild life foundation sanctions the project and provide the funds for conservation. This organization is mainly stressing on reducing the landbase pollution and sedimentation around the coral reef, as well as it is also preparing the strategy for coral reef management. A coral reef is destroying due to following reasons: -

1. Over exploitation
2. Pollution
3. Habitat loss
4. Invasiveness
5. Bleaching and Global climate change
6. Destruction of complex marine ecosystem

For conserving coral reefs, agencies are involved for mapping, monitoring, management strategies and research on conservation.

Review Questions

1. What do you understand by Mangroves?
2. What are the different strategies made at an international level for in-situ conservation.

CHAPTER 5

STRATEGIES FOR CONSERVATION—EX SITU CONSERVATION

LEARNING OBJECTIVES

- Principles and Practices
- Botanical Survey of India
- National Bureau of Plant Genetic Resources (NBPGR)
- Indian Council of Agricultural Research (ICAR)
- Council of Scientific and Industrial Research (CSIR)

Principles and Practices

Botanical Gardens

Botanical gardens are the places where high biodiversity is indicated. Different Universities and organizations maintain the botanical gardens. In these gardens, plantation is carried out in a systematic manner. Some important Botanical gardens are:

National Botanic Garden, Lucknow

It was constructed by Nawab Sadat Ali Khan and named as Sikandarabad. Later it was named as NBG. Its first director was Dr. K. N. Kaul, and this park is expanded in 75 acres area. It is situated at the bank of Gomti River. It is having Citrus orchard, Mango orchard, Guava garden, Banyan point, Rosanium, Woodland, laboratories, museum, nursery, aquatic garden, Fern house, Palm house, Orchid house, Cactus house, Hydroponics laboratory etc. Here, medicinal plants are also grown. In the museum, higher and lower plants are collected. It is having one library also.

Lloyed Botanical Garden, Darjeeling

It is situated in Darjeeling near Eden Sanatorium, and situated at 6000 feet at the East Himalayas. In this garden, cinchona nursery and bulbils plants are grown. Its area is 40 acre and in its exotic section, temperate plants are grown and in miscellaneous section, plants from Burma, Nilgiri and South India are cultivated. Here, about 1500 species are available which have been collected from 13 countries. It is having 50% Himalayan plants, 14% Japanese, 7% from North America, 6% from Australia, 5% from China, 4% from South America, 3% from Tropical Asia, 2% central Asia and 1% from Burma.

Royal Botanical Garden, Sibpur, Calcutta

Robert Kyd founded it in 1787, which was its first director. Mainly, here cinchona was cultivated. The head quarter of BSI is Royal garden. Here about 15000 species are available, in which trees; shrubs, herbs, grasses, orchids and ferns are available. Here, one large Banyan tree is present. Its age is about 1000 years. It publishes the journals and monographs. In the library, about 25,000 journals and books are available. Here, the plants from Europe, Asia and Australia have been collected.

State Garden, Shillong

It is famous for Gymnosperms; here *Taxus baccata* and *Nepenthes Khasiana* are main species.

State Garden, Mussorie

This is the garden of Gymnosperms and the main species in Ginkgo biloba.

State Garden, Nainital

It is also the garden of Gymnosperm, and specific species is *Ginkgo Biloba*.

Forest Research Institute, Dehradun

It is major botanical garden for Gymnosperm. Here, Juniperous, Taxodium, Cupressus, Pinus, Podocarpus, Araucaria and Agathis have been protected.

State Garden, Shimla

It is mainly for Pteridophytes and Gymnosperm.

Shalimar Botanical Garden, Srinagar

It is the most beautiful garden of India. Here Angiosperm and Gymnosperms, both are grown.

Lalbagh Garden, Bangalore

It is the garden of Angiosperms and Gymnosperm both.

Field Gene Banks

It is also known as vital or living gene bank. Actually many species cannot be preserved for longer time. So for maintaining its vitality continuous living status is maintained. In the major gene banks, 2-5 acre area is kept for field gene banks. In this area different green houses are constructed, where different environment is artificially managed. In these green houses all those species are grown, which are collected from different area. So it is mini botanical garden. Whenever we need the material then it can be grown at large scale and then used. Likes NBPGR approximately 2 acre area is kept for this pur pose. For conservation of aromatic and medicinal plants 2 acre area developed in national gene bank.

Field gene banks are natural places where plants and animals are growing in their habitats. In India major field gene banks are present as national parks, sanctuaries and biosphere reserves. Some important field gene banks are following:

Simalbara Sanctuary

Located in Paonta Valley of Sirmour District, this area bears beautiful dense Sal forests with grassy glades. This is probably the most picturesque area of Shiwaliks. There is a perennial stream in the area. Goral, Sambhar and Chittal can be easily seen here.

Churdhar Sanctuary

Churdhar peak, with height of 3647 metres is the highest peak in outer Himalayas.

Maharana Pratap Sanctuary

This lake sanctuary is a big attraction for migratory ducks from Siberian region during winter. Clean blue water all around with the panoramic view of Dhauladhar Ranges and Kangra Valley make the visit to Ransar Island an unforgettable experience. Black buck and Cheetal on the island along with Surkhab, Cranes, Pintails and variety of water birds welcome the visitors on the Island.

Manali Sanctuary

This sanctuary starts about 2 km from Manali town. It forms the catchment of Manalsu khad. A bridle path from Manali log huts/ Dhungri temple passes through dense Deodar, Kail, Horse chestnut, Walnut and Maple forests.

Chail Sanctuary

The Deodar and Oak forests with grasslands around the township are the abode of wildlife. One can see Sambar, Goral and Cheer Pheasants at Blossom and Jhaja. Trekking from Chail to Gaura and Chail to Jhaja is common and rewarding as one is sure to see wildlife and beautiful snowy peaks.

Great Himalayan National park

The National Park with an area of 620 sq km is located in Kullu District and has the representative area of temperate and alpine forests of Himachal. It has some the virgin coniferous forests of the State. Vast areas of alpine pastures and glaciers cap this park. This area has many important wildlife species of Western Himalayas, like Musk deer, Brown bear, Goral, Thar, Leopard, Snow leopard, Bharal, Serow, Monal, Kalij, Koklas, Cheer, Tragopan, Snow cock etc.

Pin Valley National Park

This National Park is situated in the cold desert of Spiti Valley. Snow leopard is found in this park.

Saddle Peak Valley Park

The park started in Andaman district in 1979, covers an area of 33sq km. It is at a distance of 5 km from Diglipur; the nearest town and 200 km from Port Blair, the nearest airport and the capital of Andaman and Nicobar Islands.The forest land of the islands is covered by luxuriant and lush green and thick tropical rain forests. The vegetation is characterized by humid, warm and wet tropical climate. The fauna of this park comprises Andaman wild pig, water monitor lizard, salt water crocodile. The important birds are Andaman hill Mynah and imperial pigeon.

North Button Island National Park

The park is 60 km from the long Island town and 200 km from the airport of Port Blair, the capital of the Island. Set up in 1979 the park covers an area of.44 sq km. The fauna found here are dugong, dolphin, water monitor, lizard etc.

Middle Button Island National Park

This park set up in 1979 is spread over an area of 64 sq km in the Andaman district. It is 60 km away from the nearest town of long island. The capital town and the airport of Port Blair is at a distance of 200km. It is an island with most deciduous forests. The fauna of the park consists of spotted deer, monitor, lizard and marine species.

South Button Island National Park

Set up in 1977, the park is located in the Andaman district covering an area of 2 sq km. The nearest town is Long Island 60km and the airport is Port Blair at a distance of 200km from the park. The fauna consists of dugong, dolphin, water monitor, lizard etc.

Mount Harriet National Park

Located in Andaman district covering an area of 47sq km the park was established in 1979. It is 20 km away from Port Blair the capital town of Island. The fauna of the park is primarily Andaman wild pig.

Marine National Park

This new National Park was set up in the Andaman and Nicobar Islands at a distance of 20 km from Port Blair. The park covers an area of 281sq km. The park is spread over 15 islands of Labrynth group of Islands of the west coast of south Andaman. Each Island has distinct vegetation, which comprises littoral moist deciduous evergreen forests and mangroves in small pockets, creeks and estuarine bags. The island shores are nesting grounds for 5 species of tropical sea turtles. The coral reefs and associated coral fish are there.

Gir National Park

Established in the year 1975 and situated at a distance of about 32 km from Junagarh city. Gir National Park is spread over an area of 258.71sq km. The nearest airport, Kishod, is at a distance of 80km and the nearest railhead Sasan village is just near the park. The terrain of the park consists of deep ravines steep rocky hills and stretches of grasslands. The forest of the park consists of teak and mixed deciduous trees with thorn species of Acacia and Zizyphus in parts. The park is the last remaining stronghold of vanishing Asiatic lion-classified as one of the world's most threatened species. Other fauna consists of leopard, panther,

nilgai, chital, chinkara, chausingha, wild boar, crocodile, monitor lizard. The common bird is peafowl.

Velavadar National Park

This park is situated in Bhavnagar district spread over 34 sq. kms. The park was set up in 1969. The nearest town is Ballavpur, 32 km from the park. The nearest airport Bhavanagar is at a distance of 72 km and the nearest rail head, Dhola, is 52 km away. The fauna of this park are black buck and wolf.

Vansda National Park

Set up in 1976 in the district of Bulser, this park covers an area of 24 sq.km. The nearest town and the railhead is Daghi, 3 km away from the park. The nearest airport is Baroda, 249 km away. The indicative fauna comprise the leopard and peafowl. The most suitable period for visiting the park is from December to January and April to May.

Marine National Park

This park covers an area of 163 sq. km. In the Gulf of Kutch in Jamnagar district. The park was setup in 1982. The nearest town from the park is Jamnagar at a distance of 7 km. Jamnagar is also the airport and the railhead for visiting the park.

Dachigam National Park

This park started in 1981 in Srinagar district, covering an area of 141sq.km. The capital Srinagar, 32 km away is the nearest town and airport. The railhead is at Jammu, 315 km form the park.

The animals found in the park are leopard, snow leopard, Kashmir stag, musk deer, serow, Himalayan marmot, hangual, baboon, black bear and brown bear. Pheasants koklas, barred vultures, golden eagle are common. Its importance lies in being home of the last viable population of endangered Hangul or Kashmir stag.

Kishtawar National Park

The park was started in 1981, covering an area of 310sq. km in Kishtawar district. The nearest town is Kishtawar at a distance of 60 km. The airport and railhead for the park are at Jammu at a distance of about 245 km.The fauna of the park include musk deer, Kashmir stag, Languor markhar, ibex, Himalayan tahr, black bear, leopard cat, leopard and snow leopard. The birds commonly found are monal pleasant, golden eagle, koklas, golden oriole, flycatcher.

Hemis High Altitude National Park

This park was set up in the year 1981 at Leh. It has an area of 3550 sq. km. The nearest town and airport is Leh, 30km from the park. The nearest railhead Jammu is at a distance of 695km. The elevation of park varies from 3140 m to 5854 m from the mean sea level. The temperature varies from 20°C to 40°C. The fauna which can survive in these topographic and climatic conditions comprise snow leopard, srapu, bharal, ibex, red fox, rhesus macaque, Hanuman languor, wolf and marmot. The common birds are snow cock, chukor, magpie, Himalayan whistling thrush etc.

City Forest National Park

The park has an area of 9.07 sq. km and is located in the proximity of the capital city of Srinagar. The Srinagar airport is 12 km from the park.

Bandipur National Park

The park was established in the year 1974, in the district of Mysore. The park has an area of 874 sq. km. The nearest railhead is Nanjangud 55 km and the airport is Mysore 80 km away from the park. The landscape is hilly, traversed by rivers and gorges. The tree crop consists of dry deciduous and miscellaneous species. The animals found here are tiger, leopard cat, sloth bear, four horned antelope, elephant, flying squirrel, mouse deer. The reptiles are mugger and monitor lizard. The main birds are spoon bill, jungle fowl, partridge, bush quail, wood peckers, teel and coot.

Bannerghata National Park

This park is situated in the district of Bangalore and extends over an area of 104 sq. km. It was started in1974. Bangalore which is at a distance of 25km from the park serves as the airport and railhead. The forest type of the park is moist deciduous teak forest. The fauna comprise elephant, sloth bear, chital, barking deer, gray partridges, bush quail and jungle fowl.

Nagarhole National Park

This park situated in Kodagu and Mysore districts extends over an area of 644 sq. km. The nearest town from the park is Kutta, 7 km away. The nearest railhead is Mysore, 90 km away from the park and the nearest airport is Bangalore at a distance of 220 km. The park consist of semi-evergreen forests, moist deciduous forests and dry deciduous forests. The fauna comprise elephant, tiger, panther, bear, chital, sambar, bison, flying fox, giant Indian squirrel, jungle fowl and partridges. Reptiles found are common cobra, marse crocodile, lizard, monitor, python etc.

Kudremukh National Park

The park is situated in South Kanara and Chickmagalur districts over an area of 600 sq.km. The nearest town is Chickmagalur at a distance of 80 km. The nearest railhead and airport are at Mangalore at a distance of 180 km. The terrain of the park is hilly and undulating. The forest type is semi evergreen. The fauna found are leopard, tiger, sloth bear, Indian gaur, lion tailed macaque, sambar, mouse deer and a host of reptiles. Lion tailed macaque is of special attraction.

Anshi National Park

The park is situated in Uttar Kannada district spreading over an area of 250 sq. km. The nearest town is Dandeli at a distance of 60 km. Dandeli is also the railhead. The nearest airport is Belgaum at a distance of 150 km.The terrain of the park is from undulating to steep slope. The forest types are semi-evergreen. The fauna found are tiger, black-panther, leopard cat, gaur, elephant, sambar and a variety of birds and reptiles. Black panther is a special attraction

Kanha National Park

This park is situated in the heart of Sal forests of the Central high lands of Mandla and Balaghat districts. It covers 940 sq. km in area. It was set up in 1995. The park has sparsely wooded grassy plateau, sprawling slopes with lush green, trees and bamboos. There are also plenty of smaller plants, creepers and mushrooms. The landscape, rich in vegetation presents a spellbinding view and is eminently suitable for providing shelter to a variety of mammals and birds. This area was initially made a sanctuary in 1955 to protect the magnificent barasingha-swamp deer from extinction. The fauna of the park consists of barasingha, cheetal sambar, black duck, barking deer, gaur, hog deer, chausingha, bison, boar, tiger, leopard, hyena and wild dog. It is also the tiger reserve under project tiger. The number of tigers has doubled and barasingha have crossed the 450 mark. There are nearly two hundred bird species such as storks, teals, pintails, egrets, peafowl, partridges, doves, pigeons, cuckoos, eagles, kites, etc.

Bandhavgarh National Park

Situated in Shahdol and Jabalpur districts, the park with an area of 437 km was set up in 1968. The nearest town from the park is Umaria, 35 km away. This town is also the nearest railhead. The nearest airport is at Jabalpur at a distance of 160 km. The park contains moist deciduous forests with Sal and other trees with large stretches of grass lands with bamboo groves. The fauna consists of tiger, panther, leopard, gaur, chausingha, nilgai, chinkara, sloth bear, bear, wild boar, and a variety of birds.

Madhav National Park

Set up in the year 1959, the park is spread over 337 sq km in the district of Shivpuri. The nearest town is Shivpuri 6 kms away. The park consist of dry forests of anogeisus lotifolia. The fauna found are tiger, panther, leopard, spotted deer, black buck, sambar, hyena, chausingha, langur, nilai, crocodile and python. The spoonbills, waterside birds and demoiselle cranes are there.

Panna National Park

Spread over an area of 543 sq km in the districts of Panna and Chhatarpur, this park was established in 1981. The forests of the park are tropical dry deciduous. The fauna found are leopard, panther, tiger, chinkara, sloth bear, wolf, wild pig, nilgai, gharial, mugger, crocodile, and peafowl.

Satpura National Park

The park is located in the district of Hoshangabad covering an area of 502 sq.km. The nearest town is Pamchamarhi. The fauna comprise leopard, tiger, barking deer, Sambar, nilgai and bison. Hornbill and peafowl are the common birds.

Van Vihar National Park

This park was established in 1979 in the district of Bhopal with an area of 4.45 sq. km. The state capital is only 3 km away from the park. Bhopal airport and railhead are at a distance of 12 km and 7 km respectively from the park. The fauna of the park comprise leopard, tiger, ratal, bear, Sambhar, black buck etc.

Fossil National Park

Established in the year 1983. The fossil National park is located in the district of Mandala in an area of 0.27 sq km. The park contains botanical fossils.

Pench National Park

This park was established in 1979 in the district of Seoni in an area of 293 sq km. The park contains dry mixed deciduous forest. The fauna of the park comprises tiger, leopard, sloth bear, sambar, gaur, chital, barking deer four horned antelope wild dog and wild boar.

Tadoba National Park

This park was set up in 1955 in Chandrpur district and is spread over an area of 116.55 sq km. The park is covered with deciduous forests featuring teak around Tadoba lake. The

fauna consists of leopard, leopard cat, pangolin, tiger, panther, sloth bear, gaur, sambar, cheetah, nilgai, chinkara, crocodile, python and Bengal monitor lizard.

Nawegaon National Park

Established in 1975, the Nawegaon National Park is situated in Bhandara district in an area of 134 sq km. The fauna consist of leopard, tiger panther, sloth bear, fishing cat, four horned antelope, sambar, nilgai, python, peafowl and migratory birds. There is a lake in the park, which attracts a large number of migratory birds during the period from January to April.

Sanjay Gandhi National Park

This park was established in the year 1983 in the district of Thane and Bombay in an area of 86.96 sq km. Most of the forest is dry deciduous type with a few patches of evergreen and semi-evergreen forests towards the Kanheri caves. Plant species are mangrove, jambal, teak. About 1,000 species of flowering plants are present in the park. The fauna of the park consists of panther, jungle cat, mongoose, four-horned antelope, sambar, mouse deer, wild boar, languor, monkey, magar and crocodile. A variety of water birds, of prey and vultures, quails, ring fishes, owls, parakeets are found. Amphibians, fishes turtles, python, snakes and a large variety of butterflies and moths also flourish in the park.

Gugmal National Park

This park is spread over an area of 361 sq km in the district of Amaravati. The vegetation of the park is of dry deciduous type. The mammals found in the park are leopard, panther, tiger, sloth bear, fishing cat four horned antelope, sambar, barking deer, wild beer, cheetah etc. Python is also found. The bird life is plentiful.

Keibal Lanjao National Park

This park was set up in the year1975. Spread over an area of 40 sq km. It is located in the districts of Imphal and Bishnupur. The fauna of the park comprise brow antlered deer, hog deer, wild goat, leopard cat, fishing cat and water birds.

Balphakram National Park

This park has been established in the west Garo Hill district in an area of 220sq km. The vegetation consist of tropical moist deciduous type. The predominant species is moist hill sal. Mammals found in the park are binturong, clouded leopard, leopard cat, wolf, sloth bear, elephant, loris, serow, reptile found is python. The birds are hornbill, hoolock etc.

Nokrek National Park

This park is also located in the west Garo Hills District. Its area is 68 sq.km. The forests of the parks are tropical semi-evergreen and moist deciduous. Mammals found in the park are capped languor, clouded leopard, leopard cat, fishing-cat, golden cat, Pangolin, wild buffalo, elephant, serow and tiger. Reptile living in the park is python. Birds found are hornbill, peacock, pheasant, hollock etc.

Ranthambore National Park

Set up in 1955, Ranthambore National park is situated in the district of Sawai-Madhopur, at the function of Aravalis and Vindhyas covering an area of 392 sq km. The land consists both of steep slopes and gently rolling plateau on the hill top. The forests are dry deciduous dominated by dhok trees interspersed with grasslands. There are scattered pools to provide water to the wild animals. The well forested park harbours diverse fauna which include tiger, leopard, wild boar, caracal, sloth bear, ratel, hyena, civet, jungle cat, sambar, chinkara, nilgai, four-horned antelope, python, cobra, crocodile, partridge, green pigeon, red spur fowl, peafowl, parakeet, teal etc.

Sariska National Park

The park was set up in 1982 in the district of Alwar covering an area of 274 sq km. The tract of the park is mainly hilly with two plateaus. The forests are dominated by dhok. The fauna of the park comprise tiger, leopard, panther, wild boar, hyena, jungle cat, civet, four horned antelope, sambar, cheetah, ratel, caracal, chinkara, nilagi, partridges, green pigeon and pea fowl.

Keoldeo National Park

The park set up in 1981 in Bharatpur district, 2 km away from Bharatpur town, covers an area of 29 km. The park has tropical dry deciduous forest type. Some 282 species of trees, shrubs, climbers, grasses and herbs are found here. Out of these ninety one species of plants are acquatic.

The park is often referred to as paradise for birds and is famous for the variety of indigenous and migratory birds, both aquatic and non aquatic. The fauna of the park are Siberian crane cormorant, stork, spoonbill, quail, coot, heron, teal, tern, sambar, cheetah, black buck, wild boar, civet etc. The Siberian crane which breed in Siberia usually visit this park during November- December after covering a distance of 4,000 km and go back in March. This species is critically endangered. The number of those cranes visiting the park has dwindled sharply from 100 in 1976 to just 5 in 1993.

Guindy National Park

This park spread over an area of 27.6 sq km. is situated in Madras district. The park was set up in 1976. The fauna of the park are chital and black buck. There is also a snake park.

Marine National Park

This Marine National Park is located in the districts of Tirunelveli and Ramanathapuram, covering an area of 6.25 sq km. Spread over 21 Islands. The forests consists of littoral scrubs in patches. Some Islands have babul plots raised artificially. The fauna found are several species of birds, squirrel, hare, dugong, dolphin, sea turtles etc. All the islands are egg laying sites for not less than six species of turtles.

Indira Gandhi National Park

The park covers an area of 118 sq km in the district of Coimbatore. The forests of the park are from tropical deciduous type to semi-evergreen and evergreen containing teak, rosewood and other tropical species. The wild life species found in the park are elephant, tiger, leopard, lion tailed macaque, civet, sloth bear, gaur, nilgiri languor, crocodile, python, peafowl etc.

Mudumalai National Park

Situated in the Nilgiri district the park extends over an area of 230 sq km. The Bandipur National Park of Karnataka is contiguous with this park separated by river Moyar. Kerala forests adjoin this park. The park consist of tropical moist deciduous hill forests. It has thick forests of teak and eucalyptus and dense groves of bamboo. The fauna found in the park are tiger, panther, sloth bear, wild dog, elephant, gaur, mouse deer, pigs. The avifauna include great black wood pecker, barber, Malabar gray horn bill, owl, parakeet, hawk eagle and green pigeon.

Corbett National Park

Previously known as the Hailey National Park, this park is situated in Kalagarh and Ramnagar Forest Divisions in Garhwal and Nainital districts. It spread over an area of 521 sq km and has the distinction of being the first National park of the country. It was set up in 1931. The legendary land of Jim Corbett is a paradise for nature lovers. It covers the majestic ranges of the Himalayas. Patlidoon bordering the river Ramganga and undulating Shivaliks with flat plains known as "Chaurs". Here is a dynamic ecosystem with a variety of cover and trees of Sal, Khair, Kisson, etc. capable of sustaining diverse fauna. The fauna consists of elephants, tiger, panther, wild boar, sloth bear, leopard, cat, jungle cat, cheetah, swamp deer, hog deer, barking deer, nilgai, languor, rhesus monkey, nuggar gharial, monitor lizard, python, peafowl, jungle fowl, partridges etc.

Dudhwa National Park

Situated in kheri district the park was set up in 1968 covering an area of 498 sq km. The forest is covered with sal trees interspersed with marsh lands and grass lands. This park is notable for its marshy flats of grass. The fauna consist of sambar, swamp deer, cheetah, hog deer, barking deer, crocodile, python, peafowl, partridges, etc. It is home for endangered swamp deer or barasingha.

Valley of Flowers National Park

Valley of flowers National Park was set up in 1981 in Chamoli district covering an area of 87 sq km. The fauna in the park include snow leopard, musk deer, Himalayan kthar, monal and pheasants.

Nanda Devi National Park

This park is also situated in Chamoli district. It was established in1980 covering an area of 630 sq km. The animals found in this park are black and brown Himalayan bear, snow leopard, barrel, musk deer, Himalayan thar, goral, panther, sambar, wild boar, monal, pheasant, snow pigeon, green pigeon, etc.

Rajaji National Park

This park was established in 1966. It is situated in Siwaliks of Saharanpur district covering an area of 1420 sq km. The terrain of this park is very rugged and cut up by ravines which are dry in winter. There are chirpines in the upper ridges and sal on the lower hills with Khair and Sissoo in the river beads. The fauna comprise sambar, cheetah, barking deer, leopard, bear, tiger, elephant, pig, jungle fowl, and peafowl.

Govind Pashu Vihar

The park is spread over an area of 192 sq km in Uttarkashi District. The forest of the park consists of Chirpine, scrub tropical Euphorbia scrub and oak species. The wild life species found in the park are panther leopard, snow leopard, leopard cat, the brown and the black Himalayan bear, fishing cat, musk deer, serow, thar, bharal, goral, sambar, wild boar, etc. The birds found are monal, snow pigeon, green pigeon.

Gangotri National Park

The park is situated in Uttarkashi District is a vast area1553 sq km in extent. The park provides majestic beauty of coniferous forests and grandeur of glacial world combined with lush green meadows. The forests of the park are Himalayan moist temperate type. Vegetation consist of chirpine deodar, fir, spruce, oak and rhododendrons. The fauna found are tiger, snow leopard, ibex, thar, serow, pheasants, partridges, doves, pigeons, parakeet, Himalayan barbet, bulbul etc.

Seed Banks

The collection of seeds is another important process of Ex-situ conservation, because seeds can give rise to new plant, but the vitality of seeds should be maintained. Generally, seeds are stored for short term and long term. For the short term storage lower temperature is maintained which is 0 to – 4°C. For long term storage, –20 to –25°C temperature is maintained. For the seed storage, following method is adopted:

Drying

Basically, moisture can damage the seed and chances of infection increase. So, seeds are dried during first 6-8 weeks, so the humidity becomes 15% to 3%. It is carried out with heating element and cooling battery.

Packaging

Dried seeds are hygroscopic, so these are stored at lower air humidity that's why seeds are packed into aluminium foil bags.

Storage

Generally, these seeds are stored in the large freezers or in cold rooms, where temperature should be less than –20º C. Generally use of freezers is economically cheap.

Management of collection

For the management of collected seeds, necessary equipments are needed, as: —seed processing laboratory, drying room, seed moisture analyzer, germination cabinet and deep freezers.

In Vitro Repositories

When plant extracts and chemicals are preserved in pure form, then it is known as repository. Generally, all the gene banks maintain their repositories also, like: National gene banks for medicinal and aromatic plants (NGBMAP) are maintaining the repository of medicinal plants, where active chemical compounds are collected or isolated and develop a library. These are used as marker phytochemical compounds, like: - in NGBMAP, repository of 303 pure compounds and 461 plant extracts is ready. These plant extracts have been collected from more than 80 medicinal plants, and these are used as reference material. Some important plant extracts are following: —

		Origin	Nature
(1)	Aegal Marmelos (leaves)	: — Lucknow	Alcoholic
(2)	Solanum Sp.	: — Lucknow	Alcoholic
(3)	Withania Sominiferrum	: — Lucknow	Alcoholic

Similarly, repository of 2-D fingerprints is also available, where plant extracts of many species have been kept, like *Albezzia Leibeck*, *Matrricaria* species, *Sesbania* species ets. The repositories of dry plant material and live gene bank is also maintained, like *Adensonia*

digitata, Rubia cardifolia, Cyperus Rotundus, Lupha cylinderica, and Zizypus ets. The phytochemicals have also been obtained in pure form, like crude alkaloids from Adathoda and ursolic acid. Hentriacentanone from Launia, B amerone from Tridex, Withefarin from Withania Somniferrum, coleocol from Coleus, Stagmosterol from Butea.

Cryobanks

From the nature, species are continuously disappearing due to different reasons, because:

(1) Destruction of habitat

(2) Increasing pollution

(3) Overexploitation of species

(4) Global change in environment

So, many species are extincted from the nature and many at the level of extinction, which are known as endangered species, and all the conservation efforts are for protection of endangered species. Although in the natural zones, species have been conserved, but there is also the chance of extinction. That's why, for the conservation of species, new strategy has been proposed, which is related with Ex-situ conservation. In this process, germplasm are collected from the nature and these are preserved as living content. The places where different species collected from different areas are kept are known as gene banks. When species are preserved at very low temperature, then it is known as cryopreservation, so the place, where approxmetaly –96°C temperature is maintained, is known as cryobank. Generally, pollens, ovules and tissues are preserved at this temperature. These tissues are having the capacity to regenerate.

The method of preparation of cryobank is following: First of all, tissue is obtained in a standard condition, which is grown in 6% mannitol medium, and then cryoprotectand are used in it., which are 0.5%DMSO, 0.5M glycerol and 1M sucrose. This solution is then transferred into the test- tube, and then it is freeze for one minute at 1°C and temperature is reduced up to –35ºC and it is conserved in liquid nitrogen. When it is required, then test tube is transferred into hot wanter and then to the semisolid medium, and later on, tissue is transferred on the liquid medium. This process has done cryopreservation of different parts of plant.

	Species	Culture system
(1)	*Acer Pseudoplantanus*	cell suspension
(2)	*Atropa Belladonna*	cell suspension, anther pollen
(3)	*Capsicum Annum*	cell suspension, Callus
(4)	*Daucus Carota*	cell suspension, somatic embryo
(5)	*Nicotiana Tobaccum*	callus, pollen, embryo, anther

(6)	*Oryza Sativa*	cell suspension, callus, anther
(7)	*Zea Mays*	cell suspension, callous
(8)	*Arachis Hypogea*	shoot tip
(9)	*Ipomea Batatas*	shoot tip

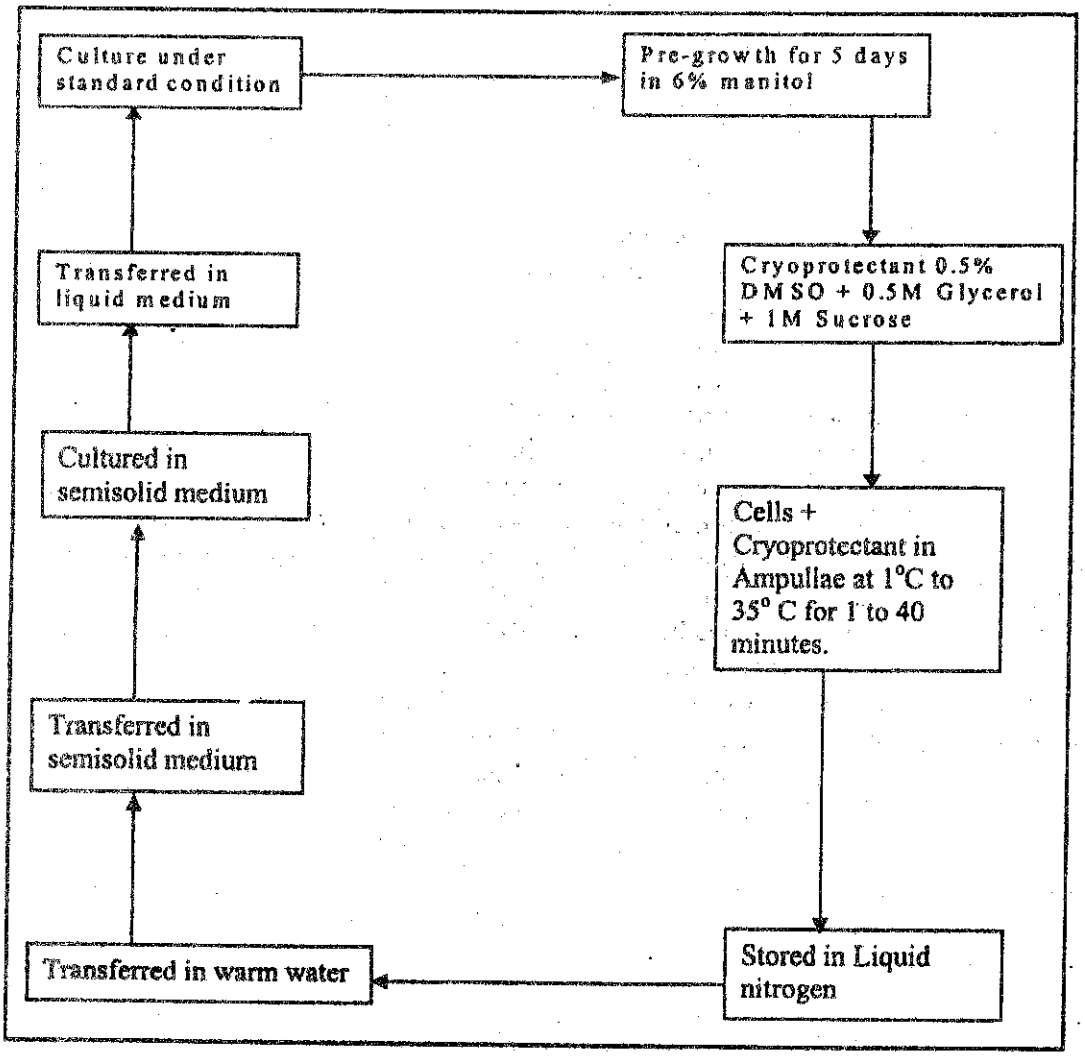

Figure 5.1: Method of cryopreservation and cause after preservation.

(10)	*Pisum Sativum*	shoot tip
(11)	*Hordeum Vulgare*	zygotic embryo
(12)	*Lycopersicon Esculentum*	zygotic embryo
(13)	*Triticum Aestivum*	zygotic embryo

In the NBPGR also, cryobank is maintained, where different species were preserved. It is India's largest cryobank. Basically, seeds and pollens, because during cryopreservation, crystallization of water takes place and cells rupture.

Botanical Survey of India

History and Development

Though modern botanical studies in India started with the revival of British and precisely with the establishment of botanical garden at Sibpur, Poona, Saharanpur and Madras under the local Governments mainly to cultivate the plants of interests in commerce and trade, but these centres were intended to be source of botanical information as well. Subsequently, to maintain the efficiency and standard, it was felt to co-ordinate the work at different establishments under an eminent botanist. Under these and similar circumstances establishment of an institution to explore the plant resources of the country was conceived and Botanical Survey of India was formally constituted on 13th February 1890. Sir George King, originally appointed as superintendent of Royal Botanic Garden, Calcutta in 1871 took the charge as its first ex-officio Director. The Survey with its headquarter at Calcutta co-ordinated the botanical works of regional centres and simultaneously intensified botanical explorations, and as a result several important documents and monographic works were published during the period, whose mention may be made of the regional floras viz. Flora of the Bombay Presidency by T. Cooke (1901-8), Flora of the Presidency of Madras by J.S. Gamble (1915-36), Bengal Plants by D. Prain (1903), Flora of the upper Gangetic plains by J. F. Duthie (1903-29) and the Botany of Bihar and Orissa by H.H. Haines (1921-25) to add to the monumental work of Sir J.D. Hooker's Flora of British India (1872-1897). However, due to lack of funds and man power of its own, activities of the Survey gradually diminished and became almost non-functional after the retirement of C.C. Calder as Director, where after for a longer period the Survey consisted of Curator, Industrial Section, Indian Museum, Calcutta and a systematic Assistant in the herbarium attached to the Royal Botanic Garden, Calcutta. During this period the Industrial Section, Indian Museum with the herbarium of the Reporter of Economic Products founded on the basis of collection by: G. Watt was transferred to Botanical Survey of India.

Then, on realizing the importance of the institution in assessing the entire plant resources of the country, E.K. Janaki Ammal was appointed as Officer on Special Duty to draw a plan to reorganise Botanical Survey of India. On recommendation of the special Officer, 4 regional centres at Coimbatore (1955), Pune (1955), Shillong (1955) and Dehra Dun (1956) were established with their headquarter at Calcutta under a chief botanist in 1955 (redesignated as Director in 1963). Simultaneously a Central Botanical Laboratory was started at Calcutta, shifted temporarily to Lucknow (1957) and thereafter established at Allahabad to study potential uses of plants. The scientific wing alongwith the herbarium attached to Indian Botanic Garden was transferred to Botanical Survey of India in 1957

and named as Central National Herbarium (CAL) with a view to modernize and to act as a national repository. During this period the herbarium of forest Department of Assam was taken over and attached to Shillong herbarium in 1956, so the herbarium of Cooke's and Talbot's and Madras herbarium to Coimbatore herbarium in 1957. The organization was strengthened with setting up of 5 new regional circles at biogeographically rich areas to intensify the survey in view of preparing a ready record of floral stock of the country for future research in different fields and necessary monitorying. The Central Circle started at Allahabad in 1962, consequent upon the transfer of Central Botanical Laboratory to Calcutta. Andaman and Nicobar Circle at Port Blair and Arid Zone Circle at Jodhpur were established in 1972 while the Arunachal Field Station at Itanagar started in 1977. The 9th regional centre as Sikkim Himalayan Circle was set up in 1979 at Gangtok.

After reorganization, with the development and establishment of different regional centres, the aims and objectives of the Survey were redefined by the Programme Implementation and Evaluation Committee in 1976 with a view to encourage taxonomic research and to accelerate the scientific expertise for the preparation of a comprehensive flora of the country, under "Flora of India" project, ethnobotanical study, modernization and maintenance of herbaria and museum, and creating interests among botanists and public in general. In a recent review (1987) the aims and objectives of Botanical Survey remained unchanged except that the activities like survey and exploration of plant resources, listing of endangered species, publication of national flora, preparation of national data bank on herbarium and live collection, plant distribution and nomenclature were prioritized.

Present Organizational Set-up

Headquarters Organization

The administrative wing acts as the controlling centre of the survey located at Calcutta while the research wing consisting of Flora Division, Ecology Division, Cryptogamic Division, Pharmacognosy Division, Plant Chemistry Division, Publication Division, Documentation and Technical Information service located at Indian Botanical Garden Complex.

Unit Offices and Circles

1. Central National Herbarium (CAL) was started by William Roxburgh in 1793 and specially built in 1883 acts as the Central custodian of herbarium specimens including types (ca 15,00,000) and historical collections, exchanged material collected from all over the world and south East Asia in particular. The herbarium also maintain hand-coloured drawings, photonegatives and microfiches obtained from Kew and other renowned herbaria of the world.
2. The Indian Botanic Garden, Howrah is used for study, introduction and conservation of flora.

3. The Central Botanical Laboratory at Howrah conducts research on cytology and economic botany.

4. The Botanical Museum (Industrial Section, Indian Museum, Calcutta) for popularising the role of plants in our lives.

Regional Circles

The Botanical Survey of India has the following nine regional circles situated at different regions of the country:

a. Southern Circle, Coimbatore — Tamil Nadu, Pondicherry, Kerala, Andhra Pradesh, and Lakshadweep.

b. Western Circle, Pune : Karnataka, Maharashtra, Goa, and the major parts of Gujarat excepting arid and semi-arid regions adjacent to Rajasthan.

c. Arid Zone Circle, Jodhpur : Rajasthan and Arid and semi-arid regions of Gujarat.

d. Northern Circle, Dehra Dun : North-western U.P., Haryana, Himachal Pradesh, Punjab and Jammu & Kashmir, Chandigarh and Delhi.

e. Central Circle, Allahabad : U.P. excepting the northern parts and Madhya Pradesh Meghalaya, Assam, Nagaland, Mizoram, Manipur and Tripura.

f. Sikkim Himalayan Circle, Gangtok : Sikkim and Darjeeling District of West Bengal.

g. Arunachal Pradesh Circle, Itanagar — Arunachal Pradesh

h. Andaman and Nicobar Circle, Port Blair: All the islands of Andaman and Nicobar group.

Experimental Gardens, Arboreta, Orchidaria and Gymnosperm Sanctuary.

There are two National Orchidaria, three Experimental Gardens and one Gymnosperm Sanctuary. These are :

(i) National Orchidarium, Yercaud, Tamil Nadu.
(ii) National Orchidarium, Shillong, Meghalaya.
(iii) Mundhwa Botanic Garden, Pune, Maharashtra.
(iv) Dhanikhari Arboretum, Port Blair, Andaman and Nicobar Islands.
(v) Sankai wilderness area, Itanagar, Arunachal Pradesh.
(vi) Gymnosperm Sanctuary, Pauri, Uttranchal.

Activities

Survey of Plant Resources of the Country

A perusal of data tabulated below reveals that Botanical Survey of India has botanised about 60 per cent area of the country so far. Details of present status of botanical exploration and inventorisation in each state are following:

Table 5.1

S.No.	State	District	Protected area	Hot spot/ Fragile ecosystem
1.	ANDAMAN AND NICOBAR Islands	Andamans - 70 Nicobars - 33	Great Nicobar Biosphere Reserve, Saddle Peak National Park Mt. Harriett National Park, Galthea Bay.	
2.	ANDHRA PRADESH	Kurnool Vishakhapatnam Mahboobnagar Medak	Nagarjuna Sagar, Srisalem Wildlife Sanctuary.	Nallamalais Bhadrachalam Maredumilli
3.	ARUNACHAL PRADESH	Papum Pare Lower Subansiri East Kameng West Kameng East Siang West Siang Tirap	Namdapha Biosphere National Park, Sessa Orchid Sanctuary.	
4.	ASSAM	Barpeta Darrang Golaghat Jorhat Kamrup Karimganj Lakhimpur Morigaon Nagaong Sibsagar	Kaziranga National Park Manas Biosphere Reserve	
5.	BIHAR	Bhagalpur Giridih Hazaribagh Paschimi Champaran Purnia		
6.	DAMAN, DIU, DADRA AND NAGAR HAVELI	Daman, Diu, Dadra and Nagar Havell	Diu-Fudam Wildlife Sanctuary	
7.	GOA	North Goa South Goa		Mangroves of Goa
8.	GUJRAT	Bharuch Dangs Junagarh Surat Valsad	Gir National Park, Junagarh	Great Rann of Kutch
9.	HARYANA	Ambala Bhiwani Faridabad Hissar Jhajhar Jind Karnal Panipat Rohtak Sirsa		

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10.	HIMACHAL PRADESH	Lahaul and Spiti Una Kinnaur Sirmour Mandi		
11.	JAMMU & KASHMIR	Jammu Ladakh Srinagar Udhampur	Dachigam National Park Kistwar National Park Gulmarg Wildlife Sanctuary Trikoot Wildlife Sanctuary.	Cold desert of Ladakh
12.	KARNATAKA	Bellary Bidar Bijapur Bagalkote Chitradurga Davangere Gulbarga Kolar Raichur Tumkur Bangalore Bangalore (Rural) Hassan Mysore Chamrajnagar Chikmaglur Kodagu Koppal Uttar Kannada Dakshin Kannada Udupi Shimoga Mandya	Bandipur National Park,	Agumbe
13.	KERALA	Kasargod Kannur Malappuram Kozhikode Palakkad Thrissur Idukki Kottayam Pathanamthitta Kollam Thiruvananthapuram	Agastya Vanam Biological Park Aralam Wildlife Sanctuary, Chimmony Wildlife Sanctuary, Chinnar Wildlife Sanctuary, Iddukki Wildlife Sanctuary, Kumarakam Bird Sanctuary, Neyyar Wildlife Sanctuary, Peechi-vazhani Wildlife Sanctuary, Peppara Wildlife Sanctuary, Periyar National Park Silent Valley National Park	
14.	MADHYA PRADESH	1. Districts Panna Damoh Chhatarpur Tikamgarh Satna Sidhi Surguja Raigarh Bilaspur Raipur Balaghat Seoni Rajnandgaon Durg Bastar Jhabua Dhar Ujjain Bhopal Jabalpur	Baudhavagarh National Park, Madhav Shivpuri National Park, Kanha National Park, Panna National Park, Indravati National Park,	

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15.	MAHARASHTRA	Akola	Tadoba National Park,	
		Washim	Sanjay Gandhi National Park,	
		Nasik	Melghat Tiger Reserve,	
		Raigad	Pench National Park,	
		Beed	Kamala Wildlife Sanctuary,	
		Jalna	Dyanganga Wildlife Sanctuary,	
		Latur	Ambabarwa Wildlife Sanctuary,	
		Pune	Devalgaon Rahekuri, Wildlife	
		Nanded	Sanctuary,	
		Parbhani	Kalsubai Wildlife Sanctuary,	
		Satara	Nagzira Wildlife Sanctuary,	
		Sindhdurg	Phansad Wildlife Sanctuary,	
		Yavatmal		
		Amaravati		
		Nagpur		
		Osmanabad		
		Ahmednagar		
		Buldana		
		Bhandara		
		Chandrapur		
		GadChiroli		
		Kolhapur		
		Jalgaon		
		Ratnagiri		
		Thane		
		Sangli		
		Aurangabad		
		G. Mumbai		
		Mumbai (Suburb)		
		Dhule		
16.	MEGHALAYA	Jaintia Hills	Mawphlong Sacred Grove,	
		Ri-Bhoi		
		South Garo Hills		
		East Garo Hills		
		East Khasi Hills		
		West Garo Hills		
		West Khasi Hills		
17.	MIZORAM	Aizawal		
18.	NAGALAND	Dimapur		
		Kohima		
		Mokokchung		
		Mon		
		Phek		
		Tuensang		
		Wokha		
		Zunheboto		
19.	ORISSA	Keonjhar	Chilka Wildlife Sanctuary	Chilka Lake
		Mayurbhanj		
		Mahanadi Delta		
20.	PUNJAB	Amritsar		
		Bhatinda		
		Ferozpur		
		Gurdaspur		
		Hoshiarpur		
		Jalandhar		
		Kapurthala		
		Ludhiana		
		Patiala		
		Rupnagar		
		Sangroor		
21.	RAJASTHAN	1. Districts	Desert National Park,	
		Alwar	Gajner Wildlife Sanctuary,	
		Banswara	Jawahar Sagar Wildlife Sanctuary,	
		Baran	Keoladeo Ghana National Park,	
		Barmer	Kumbalgarh Wildlife Sanctuary,	

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		Bhilwara Bikaner Bundi Churu Hanumangarh Jhalawar Jaisalmer Jalore Jhunjhunu Jodhpur Karauli Kota Nagaur Pali Sawaimadhopur Sikar Sri Ganganagar Tonk	Ranthambhore Tiger Reserve, Siriska Tiger Reserve, Talchappar Wildlife Sanctuary,
22.	TAMILNADU	Tiruvallur Vellore Kanchipuram Thiruvanamalai Villupuram Chennai Cuddalore Perambadur Thanjavur Pudukkottai Ramanathapuram Kanyakumari Nilgiris	Indira Gandhi Wildlife Sanctuary, Agastyamalai Hills Mudumalai Wildlife Sanctuary, Mangroves Nilgiri Biosphere Reserve, ecosystems at Gulf of Mannar Biosphere Reserve, Pichavaram, Point Calimere Sanctuary, Vedanthangal Water bird Sanctuary
23.	TRIPURA	Dhalai North Tripura South Tripura West Tripura	
24.	UTTAR PRADESH	Dehra Dun Saharanpur Chamoli Pithoragarh Tehri Almora Pilibhit Agra Rudraprayag	Corbett National Park, Dudhwa National Park, Govind Pashu Vihar National Park, Nanda Devi National Park, Rajaji National Park, Valley of Flower National Park,
25.	WEST BENGAL	1. Districts Bankura Birbhum Burdwan Darjeeling Hooghly Howrah Jalpaiguri Midnapur Murshidabad Nadia	Jaldapara Wildlife Sanctuary, Sanak Beel Mahananda Wildlife Sanctuary. Salt Lake

Ethnobotany Projects

India presents a colourful mosaic of about 563 tribal communities which have acquired considerable knowledge on uses of plants for their livelihood, health care and other purposes

through their long association with the forests, inheritance, practices and experiences. With the advancement of civilization, this ethnobotanical information has been depleting at an alarming rate. Therefore, Botanical Survey of India initiated recording and documenting ethnobotanical data in early eighties in order to provide preliminary information for further critical studies leading to sustainable utilization of bioresources and also to face the challenges of biopiracy and patenting.

National Flora/Flora of India

The analysis of the data gathered from both primary (survey and explorations) and secondary (herbarium and literature) sources of information has lead to recording of about 17500 taxa of flowering plants from India. At National Level this information is being documented in the form of **Fascicles of the Flora of India** and the **Flora of India.** The former envosages detailed revisionary studies on a family, tribe or genus and involves the study of type and other authentic specimens. So far, 22 Fascicles have been brought out by the department and another two, covering family Rubiaceae (23) and Asclepiadaceae and Periplocaceae (24) are currently in press. Whereas, the latter has been planned to be brought out in 32 volumes, each covering approximately 500 taxa, to complete the inventorying of Angiospermic flora of the country expeditiously to help documentation, conservation sustainable utilisation and monitoring of these resources. So far, six volumes (vol. I: Ranunculaceae – Barclayaceae; II : Papavaraceae – Caryophyllaceae; III : Portulacaceae – Erythroxylaceae; IV : Malpighiaceae – Dichapetalaceae; XII and XIII : Asteraceae), covering about 3150, taxa have been published, whereas vol. V (Olacaceae – Connaraceae) and VI (Leguminosae – part) covering over 900 taxa are currently under publication. Besides, out of two Introductory volumes (Pt. I and II), covering general aspects of Flora of India, such as physiography; geology; climate; botanical history; phytogeographical divisions; endemism; centres of diversity and phytogeographical affinities; exotics; ethnobotanical, medicinal and palnts of other economic value; plant based industries; wild relatives of cultivated plants; endangered plants, habitats and their conservation; protected area network; botanic gardens and the statistical analysis of the flora, Part-I has already been published and Part-II is currently under publication.

The informations provided in the Fascicles and the Flora of India include up to date nomenclature citations of the taxa (incl. basionyms and synonyms); local/vernacular names; taxonomic description; phenology; habitat and ecology; distribution; status and notes covering any other interesting details about the taxon and its uses. Suitable line drawing illustrations and photographs are also been provided.

State Flora

Like National Flora/Flora of India, to bring out Flora of States/Union territories of the country is also one of the primary objectives of the BSI. The informations provided in these documents are the same as that in Flora of India except that nomenclature citations are limited, descriptions are short, distribution of the taxon is provided at district/subdivision level and selected specimens together with herbarium reference are included.

So far floras of Himachal Pradesh, Karnataka, Rajasthan, Tamil Nadu, Tripura, Goa Daman Diu and Dadar and Nagarhaveli have already been published, whereas that of Nagaland, Meghalaya, Kerala, Maharashtra, Madhya Pradesh, Manipur, Arunachal Pradesh, Sikkim, West Bengal, Andaman and Nicobar Islands have been partly published. Besides, flora of Mizoram and Jammu & Kashmir are under publication.

Studies on Rare and Endangered Species

The exploration, inventorisation and bioperspective assessment of the phytodiversity of our country during the last two decades have lead to the identification of about 1500 rare and threatened species, of both flowering and nonflowering plant groups. The rarity of or threat to a majority of them could be attributed to anthropogenic factors like habitat destruction due to grazing, urbanization and other developmental activities and over exploitation. After a critical evaluation of their status and threat perceptions, the scientists of the department have already compiled Red Data Sheets, as listed below, either already published or under publication in five volumes of the Red Data Books of Indian Plants. Besides, a tentative list of species which need conservation, has also been drawn and efforts are being made to introduce them in the Indian Botanic Garden and the chain of experimental botanic gardens of different regional circles for their *ex-situ* conservation, multiplication and scientific study.

National Bureau of Plant Genetic Resources (NBPGR)

National Bureau of Plant Genetic Resources (NBPGR) is the nodal organization in India for exchange, quarantine, collection, conservation, evaluation and the systematic documentation of plant genetic resources. It was established in 1976 in its present setup although the activities were initiated in 1946. It operates under Indian Agricultural Research Institute (IARI). Dept of Agricultural Research and Education, Ministry of Agriculture, Govt of India. It has developed its own network based on the principles of agro-ecological analogues. It has 11 regional station/base centres for carrying out the PGR activities in India.

History and Background

Plant genetic resources (PGR) form the building blocks for crop improvement. India is an important centre of diversity for PGR, and PGR management has as long history as that of domestication of crops and agriculture. However, systematic collection and evaluation started with the establishment of the then Imperial (now Indian) Agricultural Research Institute (IARI) at Pusa, Bihar, in 1905, which was shifted to New Delhi in 1935. Among the early works, wheat exploration and collection in North-west plains by Howard and Howard during 1910-1924 was the most notable.

The need for establishment of an organization to undertake activities of plant introduction and germplasm augmentation for use in crop improvement was felt as early as 1935 by the 'Crops and Soil Wing' of the then 'Board of Agriculture and Animal Husbandry'. The need was reiterated in a meeting of the Indian Society of Genetics and Plant Breeeding in 1941, which inter alia discussed the subject of economic crops. Dr. B.P. Pal, working at IARI approached the then Imperial (now Indian) Council of Agricultural Research (ICAR) to set up a unit for assembly of global germplasm under phytosanitary conditions in India. The ICAR scheme for 'Plant Introduction' commenced functioning in 1946 in the then Botany Division of IARI under the leadership of the Late Dr. Harbhajan Singh as the first 'Operational Scientist'. The unit was further expanded and strengthened as 'Plant Introduction and Exploration Organization' in the Botany Division in 1956, and later developed as a separate 'Division of Plant Introduction' in IARI in 1961. Subsequently, on the recommendations of the 'High Level Committee' constituted by the Government of India in 1970, the 'Division of Plant Introduction' was upgraded to an independent institute 'National Bureau of Plant Introduction' in August 1976 which was rechristened as 'National Bureau of Plant Genetic Resources' (NBPGR) in January 1977.

The establishment of the Bureau coincided with the advent of the Green Revolution and was in response to the realization of perceived effects of the Green Revolution on agrobiodiversity. Further, it was in accordance with the international developments in the form of establishment of the International Board for Plant Genetic Resources (IBPGR), Rome, in 1974 (now renamed as International Plant Genetic Resources Institute). The NBPGR played a pivotal role in the improvement of various crop plants and diversification and development of agriculture in India through germplasm introduction from various institutes/organizations located in foreign countries and germplasm collection from within the country and abroad and conservation thereof.

The Bureau was reorganized in the year 1978 by the then (the first) Director, Dr. K. L. Mehra, to streamline the activities in five Divisions namely Plant Exploration, Germplasm Evaluation, Germplasm Conservation, Germplasm Exchange, and Plant Quarantine. At the time of inception, NBPGR had three regional stations namely, Amravati, Jodhpur and Shimla, and also inherited the All India Coordinated Research Project (AICRP) on Medicinal and Aromatic Plants, which was in operation at IARI. To carry out the characterization of germplasm in different agro-climatic regions of the country three more regional stations, namely Akola, Shillong and Thrissur and an Experimental Farm at Issapur, New Delhi were established. The Bureau made rapid strides during 1985-87, under the able leadership of Dr. R. S. Paroda. Regional stations at Bhowali and Srinagar and base centres at Cuttack and Ranchi were established and international collaboration (Indo-UK and Indo-USAID projects) was greatly strengthened (discussed later). A regional station at Hyderabad was also started with the responsibility of plant quarantine processing of germplasm exchanged by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and imports from International Rice Research Institute (IRRI) meant for research institutes in southern India.

The All India Coordinated Research Project (AICRP) on Medicinal and Aromatic Plants came in operation in 1972 at the erstwhile Plant Introduction Division of IARI and was located at NBPGR since 1976. The AICRP on Underutilized Plants (earlier named as Underutilized and Underexploited Plants), under the VI Five Year Plan, [illegible] the AICRP on Guar in the VII Five Year Plan were established at the Bureau in the year [illegible] 1987, respectively. However, the AICRP on Medicinal and Aromatic Plants and on [illegible] were later shifted to other places (Anand, Gujarat and Jodhpur, Rajasthan, respectively).

International collaboration and infrastructural facilities were strengthened manifold during the 1980s. The first on-site double-chambered cold storage module was installed in 1983 to conserve 30,000 seed accessions of various crops, hitherto maintained in temporary improvised storage facility. The Bureau successfully implemented the Indo-USAID (1988) and Indo-UK (1989) projects to develop human resources and strengthen the conservation facilities at Headquarters as well as its regional stations. The National Genebank (NGB) equipped with the state-of-the-art technology was established in the year 1996 under Indo-USAID Project, consisting of 12 long-term storage modules with a storage capacity of 1 million seed accessions. Well-equipped cryopreservation and in vitro conservation facilities were developed to cater to the conservation of recalcitrant seed species and vegetatively propagated materials supported by the Department of Biotechnology and the 'National Facility for Plant Tissue Culture Repository' was created in the year 1986. The NGB, with the largest capacity in the world ranks fourth in terms of germplasm holdings. For strengthening the conservation activities at the regional stations, germplasm storage modules were installed and made operational at seven stations namely Akola, Bhowali, Hyderabad, Jodhpur, Shimla, Shillong and Thrissur during 1995-2002.

With the advent of the New Policy on Seed Development in the year 1988, mandatory requirements of issuing import permit before import of any seed/plant material in the country and ensuring phytosanitary standards was introduced. Based on its scientific strength and capabilities, the Bureau was identified as a nodal agency at the national level for this purpose.

With the signing of Convention on Biological Diversity (CBD) in 1993 and strengthening of intellectual property regimes in areas of agriculture and biotechnology, the modalities for access to plant germplasm changed rapidly in the last decade. To keep pace with these new developments on policy issues related to PGR, the Bureau provided technical support for evolving a suitable mechanism for PGR management.

Realizing the need for molecular characterization of the indigenous diversity and to protect the country's genetic resources, the ICAR established the National Research Centre on DNA Fingerprinting at NBPGR in 1996. Also, to document the performance of promising germplasm and promote their exchange and use, the ICAR started the registration of potentially valuable plant germplasm at NBPGR in 1996.

The Bureau moved in tandem with the developments occurring globally. Keeping in view the strength and stature acquired over the period, the ICAR approved seven sub-projects of national importance under the World Bank aided National Agricultural Technology Project.

Of these, two mission-mode sub-projects started in 1999, namely, 'Sustainable Management of Plant Diversity (NATP (PB))' and 'Household Food and Nutritional Security' were included in the Prime Minister's coveted Jai Vigyan National Science and Technology Mission.

In order to have an access to the latest information, a separate unit for computerized documentation namely Agricultural Research Information Services (ARIS) was set up in the year 1997. All the laboratories of Headquarter and Regional Stations of NBPGR were connected by e-mail, and a home page on the internet was created. Complete automation of the library for easy access was also achieved.

Recognizing the importance of PGR as a discipline, the Bureau in collaboration with the Postgraduate School, IARI, started the M.Sc. degree course in PGR in the year 1997. The Bureau, for its dedicated and meritorious services to the nation, was conferred the Best ICAR Institute Award for the year 1997.

Objectives of NBPGR

To plan, organize, conduct and coordinate exploration and collection of indigenous and exotic plant genetic resources.

To undertake introduction, exchange and quarantine of plant genetic resources.

To characterize, evaluate, document and conserve crop genetic resources and promote their use, in collaboration with other national organizations.

To develop information network on plant genetic resources.

To conduct research, undertake teaching and training, develop guidelines and create public awareness on plant genetic resources.

Development of molecular marker systems for DNA profiling of economically important plant species.

Standardization of experimental protocols, sample size and statistical methods for application of molecular technique in variety identification, DUS testing and essential derivation.

DNA fingerprinting of released and notified crop varieties, parental lines of hybrids and elite strains/genetic stocks of potential value in crop plants.

Training of manpower and development of human resource in molecular marker techniques

Organization and Structure

The National Bureau of Plant Genetic Resources (NBPGR) has its Headquarters at New Delhi, located at latitude of 28° 35′ N, longitude of 70° 18′ E and an altitude of 226 m above mean sea level. NBPGR functions under the administrative control of the Crop Sciences Division of the Indian Council of Agricultural Research (ICAR). The Bureau is headed by the Director, who draws guidelines from the Crop Science Division of ICAR, Bureau's Management Committee, Research Advisory Committee and Germplasm Advisory Committees.

The Bureau has four Divisions and two units at its Headquarters in New Delhi and 11 regional/ base/ satellite stations located in different phytogeographical zones of India. Besides this, a National Research Centre on DNA Fingerprinting (NRC on DNAF) and an All India Coordinated Research Project (AICRP) on Under-utilized Crops are also located at the Bureau. Additionally Bureau has four cells and an experimental farm.

Plant Exploration and Collection Division has the objectives to plan, coordinate and conduct explorations for collecting germplasm. Germplasm Evaluation Division is entrusted with the prime responsibility of characterization and evaluation of all the indigenous and exotic germplasm collections for their field performance and other important traits like resistance to biotic/abiotic stresses and phytochemical attributes along with maintenance and regeneration. This division has an experimental farm located at Issapur about 45km from the main campus covering an area of 40 hacters. Germplasm Conservation Division is vested with the task of conservation of germplasm of various crop plants, and to undertake basic research on various aspects of seed storage and longevity. The Division also has the Tissue Culture and Cryopreservation Unit, with the main objective to conserve economic plants, for which conventional methods of storage are unsuccessful or inadequate, through in vitro and cryopreservation techniques. Plant Quarantine Division has been vested power by Plant Protection Advisor to the Government of India, under the Plants, Fruits and Seeds Order (1989) of the Destructive Insects and Pests Act (1914), to carry out quarantine processing of the plant germplasm imported for research purposes. Germplasm Exchange Unit has the responsibility of introducing genetic resources of diverse crop plants and their wild relatives under phytosanitary conditions. It distributes the same within the country, and also exports the germplasm with requisite phytosanitary certification. In addition, the Bureau has four cells, namely PGR Policy, National Agriculture Technology Project (NATP), Agriculture Research Information System (ARIS) and Technical Cell.

The NRC on DNA Fingerprinting has developed laboratories for molecular fingerprinting of released varieties and genetic stocks of crop plants of India. It has the objectives of standardization of molecular marker systems for DNA profiling and their application in variety identification, DUS testing and essential derivation.

The NBPGR Headquarters, along with the network of 11 regional /base/ satellite stations (Figure 2) covering different agro-climatic regions, and the linkages with 40 National Active Germplasm Sites (Figure 3), constitute the Indian Plant Genetic Resource Management Systems (IPGERMS).

Status of base collection in national gene bank

(Long term conservation at –20° C)

(31st August 2003)

S. No.	Crops	Numbers
1	Cereals	1, 09, 191
2	Millets and Forages	38, 099
3	Pseudocereals	3,392
4	Grain Legumes	37,881
5	Oilseeds	31,305
6	Fibre Crops	7,954
7	Vegetables	14,928
8	Fruits	172
9	Medicinal & Aromatic Plants and Narcotics	2,276
10	Spices and Condiments	2, 130
11	Genetic Stocks	353
12	Released Varieties	1, 284
13	Duplicate Safety Samples	10, 235
14	TOTAL	2, 55, 797

Indian Council of Agricultural Research (ICAR)

The Union Minister of Agriculture is the President of the ICAR. Its principal officer is the Director-General. He is also the Secretary to the Government of India in the Department of Agricultural Research and Education (DARE). The General Body, the supreme authority of the ICAR, is headed by the Minister of Agriculture, Government of India. Its members include the Minister of Agriculture, Animal Husbandry and Fisheries and senior officers of the various state governments, representatives of the parliament, the agro-industries, scientific organisations and farmers.

Organization

The Governing Body is the chief executive and decision making authority of the ICAR. It is headed by the Director-General. It consists of eminent agricultural scientists, educators, legislators and representative of farmers. It is assisted by the Standing Finance Committee, Norms and Accreditation Committee, Regional Committees and several Scientific Panels. The Secretary, Department of Agricultural Research and Education and Director-General of the ICAR functions as the Principal Advisor to the Government of India in all matters concerning research and education in agriculture, and allied fields.

The Director-General is assisted by eight Deputy Directors-General - one each incharge of Crop Sciences, Natural Resource Management, Animal Sciences, Agricultural Education, Agricultural Extension, Fisheries, Horticulture and Agricultural Engineering. In administration, the Director General (DG) is assisted by the Secretary, ICAR, who is also the Additional Secretary to the DARE, Government of India. In financial matters, the DG is assisted by the Financial Advisor (FA).

The ICAR receives funds from the Government of India and from the proceeds of the Agricultural Produce Cess. Rs. 13,000 million were allocated to it during the VIII Plan.

Agricultural Scientists' Recruitment Board (ASRB) is an independent recruiting agency of the ICAR for its Agricultural Research Services (ARS) and equivalent technical posts and also for research management positions. The Council has a National Academy of Agricultural Research Management (NAARM), which provides required training to new entrants to the Agricultural Research Services.

This vast network of ICAR which includes Institutes, Bureaux, National Research Centres and Project Directorates has a manpower of about 30,000 personnel out of which nearly 7000 are engaged in active research and its management. Thirty Agricultural Universities (SAUs) employ about 26,000 scientists for teaching, research and extension education; of these over 6000 scientists are employed in the ICAR supported coordinated projects.

Activities

ICAR acts as a repository of information and provides consultancy on agriculture, horticulture, resource management, animal sciences, agricultural engineering, fisheries, agricultural extension, agricultural education, home science and agricultural communication. It has the mandates to co-ordinate agricultural research and development programmes and develop linkages at national and international level with related organisations to enhance the quality of life of the farming community.

ICAR has established various research centres in order to meet the agricultural research and education needs of the country.It is actively pursuing human resource development in the field of agricultural sciences by setting up numerous agricultural universities spanning the entire country. The Technology Intervention Programmes also form an integral part of ICAR's agenda which establishes Krishi Vigyan Kendras (KVKs) responsible for training, research and demonstration of improved technologies.

The council launched a National Agricultural Research Project (NARP) in January 1979 with assistance of World Bank to strengthen the research capabilities of the agricultural universities. During project's operation up to June 30,1996, 343 research centres comprising zonal stations and sub-stations have been established and strengthened under the control of the state agricultural universities. The scientists have developed income generating technologies for the farmers of 120 agro-climatic zones covering the entire country. A

strong Agricultural Research Information System is being established connecting all the ICAR institutes, state agricultural universities and their zonal research centres.

Hybrid Crops

The ICAR system has developed and released more than 2300 high yielding varieties and hybrids so far, leading to green revolution. In all, 452 high yielding varieties and hybrids of various field crops were released for general cultivation during the VIII Plan period (1992-96). These comprised of 222 cereals (rice 101, wheat 32, maize 26, sorghum 20, pearl millet 15, small millets 21, barley 7), 92 pulses (pigeonpea 15, urdbean 16, mungbean 20, chickpea 15, others 26), 75 oilseed crops (groundnut 21, oilseed brassica 14, soybean 8, sunflower 10, sesamum 11, others 9), 41 fibre crops (cotton 40, jute 1), and 12 varieties of sugarcane and 10 of tobacco. Of the 101 rice varieties including 4 hybrids, 57 were for irrigated ecosystem, 21 for rainfed uplands, 20 for rainfed lowlands and 3 for saline soils. Out of 32 varieties of wheat, 21 were for irrigated, timely sown and 5 for late sown conditions. The remaining 6 were for rainfed areas.

The Indian National Gene Bank established by the ICAR as a part of the National Bureau of Plant Genetic Resources, has conserved more than 1,50,000 accessions and samples. The capacity of this gene bank has been increased to about 1 million making it the largest gene bank of the world. It has more than 7100 accessions of underutilized crops.

The availability of the high yielding varieties and other inputs resulted in the Green Revolution in the country in the late sixties. The modern varieties of wheat developed at the premier research centre of ICAR, the Indian Agricultural Research Institute(IARI), spread fast occupying more than 50% of the area cultivated under wheat. Without this achievement, the country would have been forced to usurp 20 million hectares of forest land and land engaged for cultivation of other crops, besides arranging 40 million hectares of additional land, to meet the current level of demand for wheat.

In the world, the development of the first hybrid cotton, the first hybrid pearlmillet, the first hybrid sorghum, the first hybrid castor, the first hybrid mango are some of the milestones of the Indian agricultural research. After China, India is the second country in the world to develop its own hybrid rice. The first amber coloured commercial Triticale dwarf and high yielding wheat were also developed in India.

Yellow Revolution

The ICAR participated in the Yellow Revolution brought out through increased production of the oilseeds which was catalyzed by the Technology Mission on Oilseeds. The increase in production of different oilseeds during the period 1985-86 to 1994-95 was spectacular, 26.96% in the groundnut, 111.50% in rapeseed-mustard, 420.50 % in soybean and 74.12%

in the total oilseed crops. This resulted in saving of large part of foreign exchange being spent on the import of edible oil. In 1993-94 foreign exchange worth Rs 24633.5 million was earned through the export of oilmeal and oilcake. So far more than 300 modern varieties and hybrids of different oilseed crops have been released to the farmers.

India is the largest producer of fruits and second largest producer of vegetables in the world. It has virtually held monopoly in the trade of spices and condiments for centuries. During 1993-94 the export of horticultural products has led to substantial increase in foreign exchange to the tune of Rs. 6616.5 million. A large number of high yielding improved varieties of fruits, vegetables crops including potato, tuber and plantation crops have been evolved together with appropriate production and protection technology suitable for varying agro-climatic regions and situations in the country. The release of improved cultivars at national level have lead to substantial improvement in the overall productivity in the country.

Agricultural Livestock Spices

India has also achieved breakthrough in the production of milk, meat, egg, wool and other livestock products. There are six central research institutes and two national institutes conducting research on buffalo, sheep, goat and poultry. A National Bureau of Animal Genetic Resources is engaged in conserving the Indian animal breeds. National Research Centres on Equine, Camel, Yak, Mithun and Meat and two Project Directorates, one each on Cattle and Poultry, are developing new breeds and new technologies for increasing the productivity of the India's animal wealth. India has become the largest producer of milk. The annual production of eggs have crossed 28,000 million and broilers 300 million in 1996.

Management Resources

Research in management of natural resources of soil and water is being carried out at eight central research institutes, two project directorates, three national research centres and 15 all-India coordinated research projects. A map of the country delineating 20 agro-ecological regions and 60 sub-regions based on physiography, soil and period of crop growth has been prepared. The soil resources map of different states in 1:250,000 scale have been completed. Sustainable multiple cropping systems have been developed for different agro-climatic zones. Various pulse and oilseed combinations have been recommended as rainfed intercrops to provide higher returns per unit area. Improved methods of water-harvesting and watershed management, reclamation of saline, alkaline and acidic soils, agro-forestry stabilization of sand dunes and integrated nutrient management with increasing use of bio-fertilizers are some of the achievements of the research on resource management.

Agricultural Engineering

Activities relating to agricultural engineering are carried out at six institutes, 10 all-India Co-ordinated Projects and in a number of ad-hoc projects located nation-wide. Research in

post-harvest technology of cotton, jute and lac are being conducted at three institutes. India is the largest producer of 4-wheel tractors with more than 200,000 tractors being sold to farmers every year and more than 1.7 million tractors are being used in cultivation. About 700,000 irrigation pumps (electric motor and diesel engine driven) are being introduced annually with an estimated current population of 17 million units. In addition, nearly 73 million drought animals provide animal power equivalent to 18,250 MW and cultivate about 55% of the total cropped area. Seed-cum-fertilizer drills, transplanters, weeders, pumps, micro-irrigation equipment, sprayers, threshers and harvesters are becoming popular. More than 35 improved implements developed by Central Institute of Agricultural Engineering and various state agricultural universities have been released by the National Implement Review and Release Committee. Improved Lac technology is generating income for about 4 million, mostly tribal cultivators. Every year about 20,000 tonnes of lac is produced. Nearly 75% of this natural resin is exported to earn about Rs 880 million in foreign exchange.

Council of Scientific and Industrial Research (CSIR)

CSIR has been a major contributor of S and T inputs for evolving national policies for environmental management and to ameliorate environmental problems. This is done through the National Environmental Engineering Research Institute (NEERI), Nagpur, which is exclusively devoted to serving the sector. The other laboratories directly engaged in environmental related R and D are the Industrial Toxicology Research Institute (ITRC), Lucknow, National Geophysical Research Institute (NGRI), Hyderabad, National Institute of Oceanography (NIO), Goa, National Physical Laboratory (NPL), Delhi and the Central Leather Research Institute (CLRI), Chennai, besides the Central for Biotechnology (CBT), New Delhi, Central Fuel Research Institute (CFRI), Dhanbad, Central Road Research Institute (CRRI), New Delhi, National Chemical Laboratory (NCL), Pune and Regional Research Laboratories (RRLs) at Bhopal and Bhubaneswar have activities of value to the sector.

Activities, Environmental Management Oceanographic Studies

Under the Indian Ocean Experiment (INDOEX) measurement of the long-range transport of air pollution from South and South-east Asia towards the Indian Ocean was studied. The results revealed high pollution level over the entire Northern Indian Ocean and aerosol mass loading originating from anthropogenic activities like biomass and fossil fuel usage etc. Under the Coastal Ocean Monitoring and Prediction System (COMAPS) extensive chemical and biological observations by NIO along the Ratnagiri- Mangalore coastal stretch showed that the region was free from major contamination. A seasonal development of anoxia in shallow near shore waters was found on the western coast for the first time. This showed that in addition to the presence of toxic hydrogen sulphide, an unprecedented accumulation of nitrous oxide, a climatically important gas, was observed in suboxic waters over large areas.

Air Quality Assessment

National Air Quality Monitoring programme taken up since 1990 by NEERI has resulted in creation of valuable long-term database for 10 major Indian urban centres of pollution levels and trends of hetrogenous ionic specific and heavy trace metals. Benzene concentration were monitored in various localities of Mumbai over various seasons has shown that substitution of lead by benzene in petrol as an antiknocking agent has had its own deleterious effects.

Water Quality Assessment

In a project sponsored by a firm nine urban centres in the country were selected for analysis of physicochemical and microbiological parameters including pathogenic organisms of different water sources used for drinking purposes. This has yielded valuable information for planning of public health measures.

Environmental Isotopes for Surface Water Pollution Monitoring

Br82 radio isotope and Rhodamine WT fluorescent dye were used as tracers to monitor dispersion, dilution and residence time of discharge waste water at Mumbai. The technique has opened up avenues for monitoring sewage dispersion and bacterial die-off pattern in marine environment.

Molecular Biology and Role in Plant Conservation

In this sector CSIR has in place eleven institutions namely the Centre for Biochemical Technology (CBT), Centre for Cellular and Molecular Biology (CCMB), Central Drug Research Institute (CDRI), Central Food Technological Research Institute (CFTRI), Central Institute of Medicinal and Aromatic Plants (CIMAP), Institute of Himalayan Bioresource Technology (IHBT), Indian Institute of Chemical Biology (IICB), Institute of Microbial Technology (IMT), Industrial Toxicology Research Centre (ITRC), National Botanical Research Institute (NBRI) and Regional Research Laboratory, Jammu (RRL-Jammu). Five other institutes namely, Central Leather Research Institute (CLRI), Central Salt & Marine Chemicals Research Institute (CSMCRI), National Chemical Laboratory (NCL), National Environmental Engineering Research Institute (NEERI), and National Institute of Oceanography (NIO) carry out R&D of value to the Sector. R&D programmes were in the areas of agrobiotechnology, genetic manipulation of microbes, molecular genetics, control of gene expressions, recombinant DNA products etc. Some of the tangible achievements are following:

Menthol-mint Oil

CSIR developments have enabled India to attain leading position in the global market place in Mentha-menthol production and exports. Genotypes of Mentha arvensis, Himalaya and Kosi, developed by CIMAP enable three crops to be harvested annually, instead of two, and have higher mint output. Two new menthol mint genotypes 'Sambhabv' and 'Saksham' have been developed through in-vitro genetic manipulation. While Sambhav is a high herb and menthol yielding insect tolerant variety, Saksham shows the fine examples of plant species utilizing end product toxicity of secondary metabolites to limit their synthesis.

Vetiver

CIMAP has developed elite strains of Vetiver named Dharini, Gulabi, and Kesari, which provide nearly 30 quintals/hectare of dried roots having over 1% oil content and a saffron note unlike other Khus varieties.

Sujata

CIMAP has developed a non-narcotic opiumless and alkaloid free poppy variety called Sujata for the first time in the world. The opium-free variety could be used as a protein and oil-rich food crop with a high calorie value and serves as a healthy vegetable oil supplement for dietary control of coronary heart diseases.

Jamrosa

RRL-Jammu has developed an improved strain of Jamrosa which has better oil yield (0.8%), low citral content (2%) and higher content of geraniol and geranyl acetate (81%) and a rosaceous odour preferred by user industry.

Hops Varieties

RRL-Jammu has developed four improved aroma cultivars of hops viz. Harmukh, Soma PL-433, Jubilee and RRL-H84. Among these RRL-H-84 has been registered in USA with Crop Sciences Society of America. This is a high alpha-acid range variety and thus of commercial value.

Damask Rose

IHBT has released two new cultivars of Damask Rose, designated as IHBT Gulab-I (Jwala) suitable for sub-tropical plains and mid hills upto 1400 m altitude and IHBT Gulab-II (Himroz) suitable for temperate zone upto 2500 m altitude.

Chrysanthemum - CV. Mother

A new chrysanthemum cultivar, selected from open pollinated seedlings, named Mother Teresa was released by NBRI. It is a small flowered, white Anemone type mini

chrysanthemum which can easily be transported in small containers due to its mini habit. Thus it has all the qualities to occupy a high position in floriculture trade.

Tulips

IHBT has shown that chlorocholine chloride treatment at the early stage of flower emergence increases the bulb yield per plant by nearly 50%, bulb weight by over 100%, bulb size (circumference) by about 20%, bulblet production by 30% and weight of bulblet by over 50% as compared to the untreated plants.

Early Flowering of Bird of Paradise

Bird of paradise has gained popularity among the variety of high value cut flowers, now in great demand all over the country. Normally the gestation period from germination to blooming is 5-6 years. IHBT by application of growth regulator, GAS3 and kinetin has reduced the gestation period to two years and increased flower production by 400% involving a nominal increase in cost.

Artemisia Annua

High artemisinin yielding variety jeevanraksha of Aretmisia Annua containing upto 1.2% artemisinin in the leaves and flowers has been developed by CIMAP. Agrotechnologies have also been developed for its successful cultivation in the plains and hills of north India.

Ashwagandha

CIMAP developed a new strain of Withania (Ashwagandha), which is an important Indian medicinal plant. The new strain yields about 14 quintals of dry roots/hectare against 8 quintals obtained from the check plant.

Lippia Alba

CIMAP has developed linalool-rich (66.6%) high oil yielding (upto 0.6%) Lippia alba plant strain LAC-2 (Kavach) used in traditional medicines and control of pest infestations in food grains and offer scope for better utilization of barren lands.

Rose Oil and Rose Water

CIMAP has developed a low cost and efficient technology for the production of rose oil and rose water. A directly fired type rose oil distillation plant of 150 kg flower capacity was designed, fabricated and installed at village Devnagar in Ajmer (Rajasthan).

Tea

IHBT has developed micropropagation protocols in tea using leaf segments (patent filed) and has standardized tea shoot proliferation using liquid medium. An improved method

of tea propagation by grafting of microshoots onto decapitated tea seedlings has also been developed (patent granted in Sri Lanka and filed in Kenya). Enzymes imparting stress tolerance in tea have been identified and protocols have been standardized for production of transgenics in tea. Concerted R&D efforts have led to reduction in chemical withering period for black tea manufacture from 16-20 hr to 4-6 hr.

Microbial Manipulation

In the area of microbial manipulation a salt inducible expression system for E.Coli for over production of desired protein developed by CCMB has been licensed in USA and India; a low temperature promoter has been isolated from psychotropic bacterium useful in degradation of human refuse; IMT isolated an ABC transporter responsible for multi-drug resistance in mycrobacteria and licensed a cloned alpha amylase gene for expression in B. subtilis; a plasmid vector constructed at CDRI enables insertion sequences and transposons present in the genome of different mycobacteria to be trapped. Using this vector, a novel insertion sequence has been isolated from Mycobacterium fortuitum which is useful in diagnosis and molecular epidemiology.

RNA Import Mechanism

The mechanism of RNA import into Leishmania mitochondria has been explored for the first time and the findings give fresh insights into the molecular mechanism of the parasite.

Rnasin – Inhibitor of Ribonuclease

CCMB has developed an efficient method to isolate and prepare in the pure form, large quantities of RNasin from discarded human placenta. The process has been commercialized.

New Cell Secreting Insulin

IICB has shown that 'Carp Adipocyte' secretes immunoreactive insulin which causes hypoglycemia in rats. Hybridization of adipocyte RNA with zebrafish and rat DNA gave insulin gene expression in these cells. Based on the conserved sequence of insulin gene of different animals, oligonucleotides prepared have been used to clone and sequence adipocyte insulin gene.

Edible Rabies Vaccine

Glycoprotein G gene of a rabies virus strain has been designed at NBRI to facilitate its high level of expression in plant cells. Fifty-nine oligonucleotides of 48-50 mer length and one oligonucleotide of 66 mer were designed as part of a strategy to develop edible vaccine. The oligonucleotides were chemically synthesized and assembled to give parts of the targeted gene. After correction of errors, the fully synthesized novel gene has been expressed in plant cells.

DNA Markers

NCL has developed a "PCR based assay" to detect male specific differences in Papaya. The assay helps detect the sex of papaya plants at the one month seedling stage so that male and female plants can be planted in a desired ratio to maximise the harvest.

Diagnostic Techniques for Indexing/Screening of Viruses

Highly sensitive detection technology (RT-PCR/PCR) has been developed by NBRI for potyviruses, geminiviruses and cucumber mosaic virus. The technology is useful in quarantine and export of plant material.

Bioinculants

NBRI has developed and transferred the technology for the production of plant growth promoting bioinoculants to an Indian pharma firm.

Cloning of Antigens

NBRI has developed the cloning of antigens from tomato that reverse the process of its ripening and cell wall decay. It holds the potential to benefit fruit growers and exporters.

Department of Biotechnology (DBT)

The setting up of a separate Department of Biotechnology (DBT), under the Ministry of Science and Technology in 1986 gave a new impetus to the development of the field of modern biology and biotechnology in India. The department has made significant achievements in the growth and application of biotechnology in the broad areas of agriculture, health care, animal sciences, environment, and industry. More than 5000 research publications, 4000 post-doctoral students, several technologies transferred to industries and patents filed including US patents, can be considered as a modest beginning. Programmes with the states of Gujarat, Rajasthan, Madhya Pradesh, Orissa, West Bengal, Haryana, Punjab, Jammu & Kashmir, Mizoram, Andhra Pradesh and Uttar Pradesh have been evolved. Biotechnology Application Centres in Madhya Pradesh and West Bengal have already been started. Initiatives have been taken to promote transgenic research in plants with emphasis on pest and disease resistance, nutritional quality, silk-worm genome analysis, molecular biology of human genetic disorders, brain research, plant genome research, development, validation and commercialisation of diagnostic kits and vaccines for communicable diseases, food biotechnology, biodiversity conservation and bioprospecting, setting up of micropropagation parks and biotechnology based development for SC/ST, rural areas, women and for different States.

Organization

The Department of Biotechnology is organized on modern lines of management, viz. reducing vertical hierarchy and promoting horizontal interaction amongst the scientific groups and officers. The Department is being advised by two apex level committees viz. the Scientific Advisory Committee (SAC-DBT) and Standing Advisory Committee (overseas) SAC-O. These committees review the ongoing programmes and suggest new and emerging areas that could be supported. The Biotechnology Research Promotion Committee (BRPC) considers, recommends and reviews major inter-disciplinary project.

It is headed by Minister of human resources development.

Commitments

The Commitments of the department would include the following:

1. To be courteous, polite and prompt in dealing with public.
2. To pledge to uphold confidentiality of information disclosed.
3. It shall be the endeavor to simplify the procedures consistent with the need of the Government to minimize delays in the decision making process, consultation with the scientists, the industry and people of different walks of life to review policies and procedures and bring in changes at the earliest to provide prompt benefits to the public in the form of improved services.
4. To continuously evolve new computerized systems and supplement the existing information system in the Department to cover all administrative, financial and technical matters requiring computerized operations.
5. To promptly bring out to the public any changes in major policies and procedures through publicity in journals, magazines, seminars etc.
6. To facilitate the scientists and the entrepreneurs in promoting technology transfers, establishing a strong relationship among the academia, research institutes and industry, guidance for developing entrepreneurship and securing protection to inventions emanating from Indian labs.
7. To generate eco-friendly and consumer acceptable, easy to use and affordable biotech products and services for the common man.
8. To harness the fruits of biotechnology research for sustainable socio-economic development of the country.

DBT is mainly related with following activities:

1. Biotech product, process development, technology transfer
2. Biotechnology information system network
3. Biotech facilities and programme support

4. Biotechnology for societal development
5. Human resource development
6. International collaboration
7. Jai vigyan national science and technology mission
8. National bioresources development board
9. Patent facilitation cell
10. Research and development section

National Bioresource Development Board

Hon'ble Finance Minister had, in his Budget Speech 1999, announced the setting up of a **National Bioresource Development Board** (NBDB) under the Chairmanship of the Hon'ble Minister of Science and Technology.

Activities

To decide the broad policy framework for effective application of biotechnological and related scientific approaches for research & development and sustainable utilization of bioresources especially for the development of new products and processes.

To develop a scientific plan of action for contributing to the economic prosperity of the nation through accelerated research and development using the modern tools of biosciences. The scientific programmes to be undertaken under the guidance of the Board would be inter-disciplinary, inter-institutional, and time bound with clear cut milestones. Some illustrative areas include:

To evolve effective ex-situ conservation strategies for bioresources of potential scientific and economic value.

To develop predictive groupings of biological resources through well-established molecular lineages.

To construct gene maps of bioresources that can be used for locating useful genes.

To promote the use of biological software in the management of agricultural pests and pathogens.

To promote value addition to bioresources.

To train human resource for the achievement of above objectives.

To strengthen bioinformatics vis-à-vis bioresources.

Activities and Achievements

Digital inventorisation: Preparation of digitized inventories of all our important bioresources has been undertaken covering: medicinal plants, other economically important plants, animal, marine and microbial resources.

Natural dyes: Colouring matter was reported for the first time from 92 plants species. Twenty five Himalayan plant species have been identified as potential sources for colouring matters that are in high demand in food processing. These include members of Lamiaceae, Rubiaceae, Polygonaceae, Ranunculaceae and Pinaceae. The colouring matters isolated from *Thalictrum javanicum, Meriandra Strobilifera* and *Rumex hastatus* are suspected to be new and novel ones. Thirteen colour extracts with high tinctorial value obtained from six targeted plant species from Kerala, were also evaluated using cotton, nylon, silk, curd, cheese and butter as substrate. Some of these have potential application in textile and food processing industries.

Botanical pesticides: The screening is done for pesticidal, larvicidal, Insect Growth Regulator (IGR), oviposition, attractant, deterrent, antifeedant and repellent activities, wherever applicable.

Lac Biotechnology: The Board has recently initiated programmes on Lac Biotechnology entitled 'Biological, Chemical and Molecular Characterization of Lac Insect Host Plant Relationship'; 'Evaluation of bio-control agents and bio-rational approaches for management of lac insect predators'; 'Application of Molecular Fingerprinting for Genetic Characterization of Races and Species of Lac Insects

Sugarcane Biotechnology: A project entitled 'Development of ESTs, gene identification and transformation in sugarcane' was recently to sanctioned to Indian Institute of Sugarcane Research, Lucknow and Department of Plant Molecular Biology, Delhi University, South Campus. The objectives of the project are Construction of general and subtracted cDNA libraries in sugarcane for ESTs specific to red-rot resistance, ESTs specific to excess-water stress (water-logging), ESTs specific to deficit-water stress (drought); sequencing and database search to assign the gene function; establishment of sugarcane cDNA bank; full-length sequencing and expression profiling of selected genes and transforming sugarcane with identification genes of economic importance.

Gums and Resins: The Board has recently sanctioned a project entitled 'Novel Chemo-Enzymatic Technology for the Food Fibre from Guar/Cassia tora Gums' to Centre of Advanced Studies in Chemistry, Forest Research Institute, Dehra Dun. The objective of the project is to prepare low viscosity dietary fibre from Guar and *Cassia tora* seed gums.

Marine and coastal bioresources: Characterization of mangrove bioresources in selected locations is being undertaken using molecular marker systems to assess the nature and extent of genetic diversity in them. Initially the dominant mangrove species of the regions were selected for the studies.

Himalayan Bioresources: Three field surveys were conducted in localities such as Sangla, Kalpa, Ropa and Bhava valleys of Kinnaur and Pin valley of Lahaul-Spiti districts, H.P during 2002. Some of the plants used for medicinal and other purposes are *Aconitum Heterophyllum* (root for stomach ache), *Arnebia Euchroma* (root as hair dye), *Artemisia Maritima* (aerial part as insect repellent), *Bergenia stracheyi* (root for jaundice), *Hippophae Salicifolia* (fruits for urinary trouble), *Prunus Armeniaca* (seed oil for massage), *Viola Pilosa* (whole plant for gastric trouble), and *Rheum Australe* (root for sprains).

Training on coastal bioresource development and management – This project has been initiated at the Central Institute of Fisheries Education (CIFE), Mumbai with the basic aim of training and educating the personnel involved in various developmental activities related to coastal zone activities such as, fisheries, industries, banking organizations, NGO's and Universities

Awareness generation on bioresources among tribal and rural youth, and general public – A project for education of tribal and rural youth on bioresource conservation, inventorisation and sustainable utilization has been supported at the M.S. Swaminathan Research Foundation (MSSRF), Wayanad, Kerala. The objectives of the project are to promote knowledge on biodiversity heritage and create awareness among tribal and rural youth and to improve the quality of student educational service using a multi-(diverse)-media training programme.

Vacation Training on Bioresources for School Children

Eight vacation-training programmes on bioresources for school children have been successfully conducted during the year 2002-2003 and 2003-2004.

Review Questions

1. Write a note an Botanical Survey of India.
2. Define the role of NBPGR. What are its objectives.
3. What is the role of ICAR in making strategies for conservation in ex-situ?
4. What are the various activities performed by ICAR?