Chapter 65

Domestication of Plants & Crop Improvement

DOMESTICATION OF PLANTS

- **Domestication** is a phenomenon whereby a wild biological organism is habituated to survive in the company of, or by the labour of, human beings.
- Domesticated animals, plants, and other organisms are those whose collective behaviour, life cycle, or physiology has been altered as a result of their breeding and living conditions under careful human control for multiple generations.
- **Humans have brought these populations under their care for beneficial uses**. It may be to produce food or valuable commodities (such as wool, cotton, or silk), for help with various types of work, transportation and to enjoy as pets or ornamental plants.
- Plants domesticated primarily for aesthetic enjoyment in and around the home are usually called **house plants or ornamentals**, while those domesticated for large-scale food production are generally called **crops**.
- All the present species of cultivated plants are of wild species origin and this **process of cultivation of wild species in order to fulfil human needs is called domesticaton of plants**.
- Domestication plays foremost role in development of human civilization.
- **Effective agriculture** is the result of domestication of crop plants.
- Origin of agriculture dates back to **7000–13,000 years ago** in high and well watered lands of Indus, Tigris, Nile and Euphrates.
- According to **Carl Scanner**, **nitrogen loving plants were the first wild weed plants**, which were then brought under cultivation.
- Cultivation of plants started with the help of vegetative parts in the form of tubers, bulbs, rhizomes, etc., but later on ability of seed to develop into new plant was recognized and most of the early civilizations like Babylonian, Egyptian, etc., developed on the basis of seed-generated crops like wheat, rice, maize, barley, etc. (cereals).
- Actually, the method of obtaining plants from seeds, is known as **cultivation**.
- The earliest human attempts at plant domestication occurred in Asia.
- There is early evidence for conscious cultivation and trait selection of plants by pre-Neolithic groups in Syria: grains of rye with domestic traits have been recovered from Epi-Palaeolithic (ca. 11,000 BC) contexts at Abu Hureyra in Syria, but this appears to be a localised phenomenon resulting from cultivation of stands of wild rye, rather than a definitive step towards domestication.
- By 10,000 BC the bottle gourd (*Lagenaria siceraria*) plant, used as a pre-ceramic technology container, appears to have been domesticated.
- The domesticated bottle gourd reached the Americas from Asia by 8000 BC, probably with peoples migrating into the continent from Asia.
- Cereal crops were first domesticated around 9000 BC in the Fertile Crescent in the Middle East.
- Origin of cereals actually took place in montaineous parts of both **old world** (Asia, Africa and Europe) and **new world** (America) and present day cereals were infact wild weeds.
- **Cereals** were actually the **first group of plants,** which were **brought under domestication** because of rapid growth, sufficient amount of reserve food and weediness.
- After direct food plants like cereals, plants with cooking qualities were brought under cultivation.

- Discovery of fire was an important reason behind it.
- So, now different other food plants like pulses, oil seeds along with cereals were discovered and man turned into actual farmer.
- The first domesticated crops were generally annuals with large seeds or fruits. These included pulses such as peas and grains such as wheat.
- The Middle East was especially suited to these species; the dry-summer climate was conducive to the evolution of large-seeded annual plants, and the variety of elevations led to a great variety of species.
- Domestication was gradual, a process of trial and error that occurred slowly.
- Over time perennials and small trees began to be domesticated including apples and olives.
- In different parts of the world very different species were domesticated.
- In the Americas squash, maize, and beans formed the core of the diet. In East Asia millets, rice, and soya were the most important crops.
- Some areas of the world such as Southern Africa, Australia and California and southern South America never saw local species domesticated.
- Over the millennia many domesticated species have become utterly unlike their natural ancestors.
- Corn cobs are now dozens of times the size of their wild ancestors.
- A similar change occurred between wild strawberries and domesticated strawberries.
- After discovery of single purpose plants, multipurpose plants were known and these brought into cultivation, *e.g.,* coconut, date palm, hemp, mulberry, etc.
- Despite long enthusiasm about revolutionary progress in farming, few crops became domesticated.
- Domesticated species, when bred for tractability, companionship or ornamentation rather than for survival, can often fall prey to disease: several sub-species of apples.
- One side-effect of domestication has been causing of disease.
- Domestication of wild species is still being done and is likely to continue for a long time in future. This is because the human needs are likely to change with time.
- The wild species of little importance today may assume great significance tomorrow. This is particularly true for micro-organisms producing antibiotics, involved in nitrogen-fixation and producing timber and other commercial products, medicinal plants.
- A notable case of recent domestication is that of several members of Euphorbiaceae producing latex. The latex of these plants may be commercially used for extraction of petroleum products including petrol and diesel.

Origin of cultivated plants

- The earliest view of origin of cultivated plants is that these plants are given by god in form of gifts. Later on it was said that wild types converted into cultivated types due to their cultivation under good agronomic conditions.
- Most important contribution made by a Russian worker called **N. I. Vavilov** (1926), who on the basis of his studies reported that there are eight primary centres of origin of cultivated plants, where all grades of variations from wild type species to cultivated types occur.
- These **primary centres** are dominated by **dominant genes**. In the course of cultivation, the plants spread to different parts of the world.
- In some **areas certain crop species show considerable diversity to form although they did not originate there**. Such areas are known as **secondary centres of origin of** these species.
- The centres of origin are **also called the centres of diversity**.
- There are 8 **main centres of origin as proposed by Vavilov**- China, Hindustan, Central Asia, Asia Minor, Mediterranean, Abyssinia, Central America and South America.
- **China** – This centre consists of the mountainous regions of Central and Western China and the neighbouring low lands. It is the **largest and the oldest independent centre of origin**. It is the **primary centre of origin** for **soyabean**, **radish**, **opium**, **poppy**, **brinjal**, **pears**, **peaches**, **plums**, **oranges** and **chinese tea** and **secondary centre of origin for maize**, **rajma**, **cowpea and sesame**.
- **Hindustan** – This includes Burma, Assam, Jalaya, Java, Sumatra and Phillipines but excludes North-Western India and North-Western Frontier provinces. It is the **primary centre of origin** for

rice, **pulses** (arhar, gram, cowpea, mung), **cucumber**, **nobel canes** (*Saccharum officinarum*), **cotton**, **mango** and **banana**.

- **Central Asia** – It includes North-Western India, whole of Afganistan, Tazakistan and Uzebekistan. It is the **primary centre of origin** for **wheat**, **pea**, **linseed**, **sesame**, **onion**, **garlic**, **spinach and grape** and the **secondary centre of origin** for **rye**.
- **Asia Minor** – It is also known as Near East Centre of origin and includes interior of Asia Minor, whole of Iran and high lands of Turkmenistan. It is the **primary centre of origin** for **rye**, **alfa alfa**, **carrot**, **oat**, **fig**, **pomegranate**, **apple and nuts**. and the **secondary centre of origin** for **rape** (*Brassica campestris*) and **black mustard** (*B. nigra*).
- **Mediterrean** – It is the **primary centre of origin** for **durum wheat**, **emmer wheat**, **barley**, **lentil**, **several species of *Lathyrus***, **pea**, **beets**, **lettuce**, **onion**, **garlic and cloves**.
- **Abyssinia** – It includes Ethopia and Eritrica. It is the **primary centre of origin** for **jowar**, **bajra**, **sem**, **safflower**, **castor**, **linseed and coffee** and **secondary centre** of **origin** for **broad bean**.
- **Central America** – It includes both Mexico and Central America. It is the **primary centre of origin** for **maize**, **cotton**, **rajma**, **pumpkin**, **papaya**, **guava and avacado**.
- **South America** – It includes high mountain regions of Peru, Bolivia, Eucador, Colombia, parts of Chile and Brazil and whole of Paraguay. It is **primary centre of origin** for **tomato**, **potato**, **tobacco**, **groundnut**, **rubber and pineapple**.

Degrees of domestication

- A classification system that can help solve the confusion might be set up on a spectrum of increasing domestication.
- **Wild** – These species experience their full life cycles without deliberate human intervention.
- **Raised at zoos or botanical gardens** – These species are nurtured and sometimes bred under human control, but remain as a group essentially indistinguishable in appearance or behaviour from their wild counterparts. (It should be noted that botanical gardens sometimes exhibit domesticated plants such as some orchids).
- **Domesticated** – These species or varieties are bred and raised under human control for many generations and are substantially altered as a group in appearance or behaviour.
- This classification system does not account for several complicating factors as genetically modified organisms, feral populations, and hybridization.
- Many species that are farmed or ranched are now being genetically modified.
- This creates a unique category because it alters the organisms as a group but in ways unlike traditional domestication.

Natural and artifical selection under domestication

- **Selection** may be described as the phenomenon in which some genotypes from a population leave behind more progeny than the others.
- In nature, there is a continuous selection by natural forces, eg., temperature, soil, moisture, pests, diseases, etc.
- The genotypes more suited to a given environment leaves behind more progeny than the less adapted ones. This process is known as **natural selection**.
- The **artificial selection** (selection by man) often permits only the selected plants to reproduce. Thus, man exerted considerable selection on the domesticated plant species.
- Artificial and natural selection have led to several distinct changes in characteristics of domesticated species.

Changes under domestication

- Some important changes that have occurred under domestication are enumerated as –
  - Reduction in shattering of pods, spikes, etc.
  - Elimination of dormancy in several crop species.
  - Decrease in toxins or other undesirable substances.
  - Cultivated plants show altered tillering, branching, leaf characters, etc.
  - Decrease in plant height as in the case of cereals and millets.
  - Increase in plant heights as in the case of jute, sugarcane and forage grasses.
  - Reduction in life cycle as in the case of cotton and arhar.
  - Increase in fruit and grain size.
  - Promotion of sexual reproduction as in the case of sugarcane, potato, sweet potato, etc.
  - Variability within a variety has drastically decreased under domestication (a negative effect).
  - Preference for polyploidy, for instance, potato, wheat, sweet potato, tobacco, etc. while, diploid plants are present in nature.

CROP IMPROVEMENT

- Crop improvement **proposes to obtain crops with higher yield, better quality, resistance to disease and shorter duration which are suitable to particular environmental conditions**.
- It involves two types of measures – **improved agricultural preparation** and **improvement of crop varieties.**
- Agricultural preparation includes, application of manures and fertilizers, protection against diseases and pests, proper irrigation, improved reaping, transport and storage of products.
- **Improvement of crop varieties** is a permanent measures which creates genetic potentiality in crop plants for higher and better yield.
- Genetic improvement of crops, along with the control of important diseases of crops, are very useful in increasing food production and food quality.
- Scientists connected with improvement of crop varieties are called **plant breeders**.
- **Plant breeding** is an applied branch of botany and deals with the improvement of cultivated varieties (cultivars) of plants.
- It is the improvement in the heredity of crops and production of new crop varieties which are far better than original types in all respects.
- The **aims of plant breeding differ with the type of crop, soil, climate,** etc. However, **some common objectives** are listed below –
  - To get higher yield.
  - To improve the quality, size, shape, colour, taste and storability (keeping quality) of the produce.
  - To improve resistance to drought, diseases, frost, salinity etc.
  - To prevent the premature falling of buds, fruits etc.
  - To change the duration of the crop *i.e.*, to develop early maturing (short duration) or late maturing (long duration) crops.
  - To increase the efficiency of use of fertilizer.
  - To change the growth habit *i.e.*, to produce dwarf or long varieties, profusely branched or sparsely branched varieties.
  - To make harvesting easier.
  - To induce the adaptability of a crop to different climatic and soil conditions.
- A cultivated variety having majority of the above characters is regarded as a **superior variety**.

Methods of plant breeding

- There are **different methods of plant breeding**. They are – introduction, selection, hybridization, mutation breeding, polyploidy breeding, tissue culture, and genetic engineering.
- Different methods of breeding are based on the type of reproduction and pollination operating in a crop.

Plant introduction

- It is the process of introduction of high yielding varieties of plants from their growing locality to another, with changed climatic condition.
- **Acclimatization** is the adaptation of introduced plant in the changed environment.
- Uncontrolled plant introduction in the past are responsible for introduction of hazardous diseases (like late blight of potato, flag smut of wheat, leaf rust of coffee, fire blight of apple and pear).

Indian Plant Breeders

- **Sir. T.S. Venkatraman** – Pioneer Indian Plant breeder famous for sugarcane improvement.
- **Choudhary Ram Dhan** – Wheat breeder, who is famous for C-591 variety of wheat, which made Punjab as wheat granary of India.
- **Dr. B.P. Pal** – Famous wheat breeder, who produced many NP wheat varieties.
- **Dr. K. Ramiah** – Famous rice breeder of international fame.
- **Dr. Pushkar Nath** – Famous potato breeder.
- **Dr. Boshi Sen** – Famous maize breeder.

Historical Account

- As early as 700 BC, Assyrians and Babylonians used to cross pollinate date palms artificially.
- In 1694 Camararius proved that there is sexual differentiation in plants.
- In 1717, Thomas Fairchild produced the first hybrid plant artificially.
- In 1761, Cotton Mather recognized the process of natural selection in maize.
- During 1706-66 Joseph Koelreuter produced many hybrids in tobacco.
- During 19^{th} and 20^{th} centuries, techniques of plant breeding like, selection, hybridization, were improved. L.L. Vilmorin (France), Burbank (USA), Michurin (USSR) are some of the famous plant breeder of that time.

- But achievements of plant introduction are also numerous, eg., new plants like maize, potato, groundnut, chillies, coffee etc. are the result of plant introductions.
- Similarly, many improved varieties of different crop plants are also outcome of these introduction, eg., Ridley and Sonora – 64 varieties of wheat.
- **Quarantine** is careful examination of all the introductions for the presence of weeds, insects, and disease-causing organisms. This is because with every introduction of new variety of a species, there are also chances of coming new weeds, insect pests and diseases from other countries. Quarantine is also applied to animals and, sometimes, to humans to **reduce the risk of entry of a pathogen in the country**.
- The progeny produced by crossing two varieties, species or genera having desired genes and bringing together the useful character in it is called **hybrid**.
- Introduced plants **serve as a good source of parental material for hybridization experiments**. Introduced plants can be subjected to "selection" to get better results.
- Plants pathogens and pests may also seek entry along with the introduced plant material. They may multiply rapidly in the new climate and cause serious damage to the introduced variety. For example, pathogens like *Phytophthora infestans* (late blight of potato) from Europe (1883), *Hemileia vastatrix* (coffee rust) from Ceylon (1876), *Urocystis tritici* (flag smut of wheat) from Australia were introduced into India.

Selection

- Selection is the **oldest breeding method**. It is of **two types** – **natural** and **artificial**.
- **Natural selection** is a natural process. Evolution is the ultimate result of natural selection only. According to the Darwin's principle – "Survival of the fittest", plants which survive through the adversities of nature are preferred and the weaker ones are wiped out. Thus, nature itself selects the fittest organisms.
- In **artificial selection** the selecting agent is man. Man exploits the variations existing among the species. He picks up a few plants of better qualities from mixed populations and tries to propagate them.
- There are **three methods of artificial selection– mass selection**, **pure-line selection**, and **clonal selection**.
- **Mass selection** is the **simplest** and the **oldest method** of crop improvement **practised by farmers**. It is **practised in cross pollinated crops**.
- Plants are in heterozygous condition. Seeds of best plants, showing high vigour are collected and pooled up. These seeds are used to raise the crop in the next year.
- The same process is carried out for 7 or 8 generations. Finally they will be multiplied and distributed to the farmers for cultivation.
- Good results are obtained if the existing variations are more in the population. Mass selection is based on external characters (phenotype) only. Hence it is easy to follow this.
- **Merits of mass selection** are –
  - It is the easiest and quickest method of crop improvement.
  - It needs no scientific knowledge.
  - The newly produced variety need not be tested.
  - Pollination need not be controlled to produce a new variety.
  - Mass selection is the only method of improving wild or local varieties.
- **Demerits of this process** are –
  - Importance is given to phenotypic characters only.
  - This method is applicable only to cross pollinated crop.
  - The new variety produced is always heterozygous.
  - There is no control over pollination as a result the degree of heterozygosity increases and the desirable qualities gradually diminish.
  - It is not possible to increase the yield of a variety because importance is given to maternal characters only and yield is subjected to environmental influences.
- A **pure line** may be defined as the "**progeny of a single individual obtained by selfing**" – Sinnot *et al*.
- A group of plants obtained from a single self fertilized homozygous plant is called a **pure line**. The **term pure line** was first **introduced by W.L. Johannsen in 1903**.
- This method is mostly **applicable to self pollinated crops**. The **progeny of a pure line selection are**

similar phenotypically and genotypically.

- Sometimes minor variations may occur in a pure line. These variations are simply due to the influence of environment.
- 50-100 plants or heads are selected from the mixed population of the field before harvest and seeds are collected separately.
- The progeny of each such plant are grown in a separate line. Plants with desirable characters are selected from each line again. 25-50 seeds from such plants will be grown in separate rows in a plot.
- The same process is followed for 7 to 8 generations until a new variety is isolated.
- **Merits of pure line selection** are –
  - This is the only method to improve local varieties of self pollinated crops.
  - This method is easier than hybridization.
  - New plant varieties produced by this method are uniform, similar in phenotype and genotype.
  - This method is also useful for the production of pure lines and inbred lines in cross pollinated crops.
- **Demerits of this method** are –
  - It is a very lengthy and laborious process.
  - New characters (new genotypes) cannot be introduced into a plant variety.
  - It is not possible to improve a variety beyond a certain level of homozygosity.
  - Extreme homozygosity may result in low yield and other undesirable characters.
  - Due to high degree of homozygosity, variations among the varieties are also limited. Therefore, their adaptability to varied conditions is also poor.
- Selection of desirable clones from the mixed population of a vegetatively propagated crop is called **clonal selection**.
- The progeny of a single plant obtained by vegetative propagation is known as a clone or all the vegetative progenies of a single plant are called a **clone**.
- Clonal selection is a method of improving vegetatively propagated crops such as sugarcane, banana, potato, citrus, mango, grapes, sugar beet etc. All the plants of a clone are similar in phenotype and genotype. Just like in pure-line selection, here also, importance is given to the phenotype only.
- **Merits of clonal section** are –
  - Varieties developed by clonal selection are more stable.
  - As there is no segregation, variations do not usually appear.
  - Even after many years of cultivation, the characters are not disturbed or lost.
  - Hybrid vigour of a plant can be maintained or preserved for many generations by clonal selection.
  - This is the only method to improve the vegetatively propagated crops improved by hybridization which are also finally selected by this method.
- **Demerits of this method** are –
  - This method is not applicable to crops propagated by seeds.
  - This method is useful only to isolate best genotypes already present in the populations.
  - New genotypes cannot be developed by this method.

Hybridization

- Hybridization can be defined as mating between two (or more) individuals or lines differing in genotype. It **is the most common method of creating genetic variation**.
- The technique of hybridisation involves crossing two plants to get a new synthetic one possessing the combination of good qualities of the parental plants. Hybridisation is often done in green house under controlled conditions.
- The **process of hybridisation involves following steps** –
  - **Selection of parents:** An individual /lines used in hybridization are called **parents**.
  - **Selfing of parents** to induce homozygosity.
  - **Emasculation:** If the two parents have bisexual flowers, before the flowers of female parent open and shed pollen, their anthers are carefully removed. This is called emasculation**.**
  - **Bagging:** This is the process by which male and female plants are kept in isolation by enclosing them in bag.
  - **Pollination:** Pollen is then collected from the flowers of male parent and placed on the stigma of flowers of female parent. The seeds produced by these flowers of female parent are the **hybrid** or **F_1 seeds**.

- Hybridization or crossing leads to **hybrid vigour or heterosis**, which is defined as "**superiority of hybrid over its parents**". Selfing results in **inbreeding**.
- The **term heterosis** was **given by G.H. Shull** in 1914 (*Heteros - different; Osis - Condition*), *i.e.*, different condition of hybrid from its parents.
- Hybrid vigour has been commercially exploited in different commercial crops like maize, sorghum, bajra, tomato, sugarbeet, petunia, zinnia and cucumbers.
- Heterosis is **used in genetics & breeding**. It is the possibility to obtain a "better" individual by combining the virtues of its parents. Heterosis is often the opposite process of inbreeding depression which increases homozygosity.
- **Effect of Heterosis** – Heterosis does not affect an individual as a whole but only in separate parts such as root in carrot, tuber in potato, hypocotyl in turnip, flower in cauliflower/fruits in pea, lobia, bhindi and curcurbits etc. The effects of heterosis in these plants can be expressed in the following ways – greater height, weight, size and number of the different parts of the plants, increase in yield and growth, greater fertility and viability, more efficient seed germination, longivity, earlier flowering and maturity, and increased resistance to disease.
- **Importance of heterosis** – This phenomenon results in hybrids that have better characters. Many ornamentals and fruit trees, valuable vegetables, good quality cereals are results of cross breeding inbreeds.
- Besides plant breeding, heterosis is also practicable in animal breeding.
- When the offsprings are produced by self fertilization or breeding between closely related parents it is called **inbreeding**. It is a form of mating system in a sexual organisms.
- Thus, self-fertilization or selfing is an extreme form of inbreeding. **Inbreeding results in increase in homozygosity**.
- The most revealing impact of inbreeding is the loss of vigour and physiological efficiency of the organisms characterized by reduction in size.
- A number of lethal and defective characters appear in the population which has undergone inbreeding (selfing). "This loss of fitness in the progenies or decline in character expression with decreased heterozygosity arising from self mating is known as **inbreeding depression or inbreeding decline**.
- Haldane (1948) referred inbreeding to be – "**the enemy of vigour and yield of plant**".
- The **effects of inbreeding are of great importance in plant breeding** and are given below as –
  - Inbreeding tends to increase the genetic correlation between relatives. It determines the success of pure line inbreeding for improvement of self pollinated crops.
  - Since inbreeding split the population into genetically divergent families with little additive variation at intra-family level but ample at inter-family level, selection is effective only between family.
  - Inbreeding is useful for progeny testing since close inbreeding (selfing) is the only effective method of differentiating heritable differences from non-heritable differences (characters).
  - Inbreeding is used to develop inbreeds in cross-pollinated crops.

Mutation breeding

- Hugo de Vries was the first person who defined "**mutation as sudden phenotypic changes which are heritable**". When mutated plants are used in plant breeding, new varieties of crops are produced.
- **Sharbati Sonora and Pusa lerma** are the **two important varieties of wheat** produced by gamma rays treatment of Sonora - 64 and Lerma - Roja - 64 (Mexican dwarf wheat varieties).
- **Sharbati Sonora** is the amber grain coloured variety of wheat produced by **Dr. M.S. Swaminathan** and is **responsible for green revolution in India**.
- **In rice**, about 45 varieties upto 1992 have been produced by mutation breeding. Important ones are - **Remei variety** and **Atomita - 2**.
- **Mutation breeding has some important limitations** as –
  - Most of the induced mutations are invaluable to the breeders and many of them are lethal.
  - Mutation rate is extremely low.
  - Stability of mutants is sometimes doubtful as some mutants have tendency to revert back to original type.
  - Most of the mutations are recessive.

– The main uses fall in 3 categories – genic manipulations, chromosomal engineering and diffusing specific plant breeding problem.

Polyploid breeding

- The organism (plant) which contains more than two complete sets of chromosomes, is called **polyploid**.
- Depending upon the number of chromosomal sets, the individuals are given different names as - monoploids, diploids, triploids, tetraploids, pentaploids and hexaploids (eg., wheat).
- Polyploids are characterized by gigantism or increase in cell size and hence organ size and thus overall size. These **polyploids are used in crops improvement**, eg., triploids are present naturally in different crop plants and generally in triploids, seedlessness is present.
- Most of the varieties of banana are triploids and hence their fruits are seedless.
- These triploids are not of any use in such plants where seeds are of commercial importance.
- Polyploidy can **also be induced artificially by colchicine treatment**. Colchicine is an alkaloid obtained from *Colchicum autumnale* (Liliaceae).

Tissue culture

- This is one of the latest and most promising methods of crop improvement in such plants, where all other conventional methods of breeding fail.
- Tissue culture **technique is based on totipotent nature of plant cell or phenomenon of totipotency,** *i.e*, each and every plant cell has inherent capacity to develop into complete plant [*For more detail refer chapter* '*Plant Tissue Culture*'].

Genetic engineering

- This is the latest method of crop improvement in which instead of involving whole chromosomal set (genome), manipulation of a segment of DNA (gene) is done.
- In this technique, introduction or deletion of one or more genes is done into an organism or plant. [*For more refer chapter Biotechnology & Genetic Engineering*].

Green revolution

- Green revolution is rapid increase in agricultural output as witnessed in India during 1970s.
- It has been achieved through introduction of high yielding varieties, increased irrigation facilities, fertilizer application, weed, pest and pathogen control, multiple cropping and better agricultural managment.
- **N.E. Borlaug** – Famous Mexican plant breeder, who was awarded Nobel Peace Prize (1970) for developing high yielding dwarf wheat varieties like Norin-10, Sonora-64, Lerma rojo-64, etc. He is known as **"Father of green revolution"**.
- **Dr. M.S. Swaminathan** – He is pioneer mutation breeder. He has produced Sharbati Sonora, a variety of wheat by mutation, which is responsible for green revolution in India. Dr. Swaminathan is **called** '**Father of green revolution in India**".
- **Dwarf Rice** – A dwarfing gene, **dee-geo-woo-gen**, was noted in Taiwan. It was introduced in Rice varieties (IR-8, IR-24) by IRRI. Philippines.
- To check Grassy stunt virus, Dr. Gurudev S. Khush crossed 13 rice varieties from six countries and *Oryza nivara* (Wild Rice from Central India) to produce early maturing, high yielding and resistant variety IR-36.

Transgenic crops/plants

- The most important use of plant biotechnology is the production of superior transgenic crops/plants which are having not only the resistance against a variety of biotic and abiotic stress, but also having some improved value added properties like nutritional quality of food.
- **Transgenic plants are those plants in which a foreign gene has been introduced and stably integrated into host DNA**.
- A gene that has been transferred using the tools of molecular biology is called **transgene**.
- The **first transgenic plants** are produced in tobacco (*Nicotiana tabacum*). Some other higher plants where transgenic plants have been produced are *Lycopersicum esculentum* (tomato), *Solanum melongena* (brinjal), *Vitis vinifera* (grapes), *Zea mays* (maize), *Avena Sativa* (oat) etc.
- India has permitted the commercial cultivation of three varieties of ***Bt*-Cotton**, the **first genetically modified crop of the country**. This has been developed by **MAHYCO** (Maharashtra Hybrid Seeds Company) in collaboration with American company **Monsanto**. *Bt*-Cotton is **resistant** to **Boll-worm disease of cotton**.
- Nowadays, there is a debate on biosafety issues of transgenic plants. The key points are –

  - Potential of GM crops to become weeds.
  - Opportunities of gene flow from a GM plant to other plants.
  - Impact of growing transgenic plants on biodiversity.
  - Capacity of pests and pathogens to adapt to the cultivation of GM crops.
- The area under transgenic crops will continue to rise and thus will result in more food derived from transgenic crops are called "GM foods" or genetically modified foods.
- The main concerns about the potential of GM foods/ crops relate to –
  - Increase in toxins.
  - Introduction to allergens.
  - Changes in the levels of essential nutrients.
  - Reduced efficacy of antibiotics.

Social forestry

- **Social forestry** is raising of fast growing and multipurpose species of trees and shrubs by local people on public and common vacant lands and roadsides etc for fulfilling their fodder, fuel and small timber requirement.
- The species of plants selected for social forestry vary from one locality to another. It reduces the pressure on real forests and also manages soil and water conservation, saves dung for manure and biogas and moderates climatic conditions.
- **Important plants recommended for social forestry programme** are – *Dalbergia sisso*, *Moringa*, *Morus*, *Tectona*, *Zizypus* etc.

New and under utilized crops

- Out of about 3,50,000 known plants at this time, a few, *i.e*, about 100 plants are being used for fulfilling man's daily requirements.
- Scientists are in search of less known and under utilized crop plants, which can be used for food and other purposes and thus exploitation of traditional plants can be reduced.
- Such under-utilized and under exploited plants are known as new crops.
- **Triticale** is the **first man made cereal or crop**, which has been produced by intergeneric hybridization between common wheat (*Triticum aestivum*) and European rye (*Secale cereale*) with a view to combine characters of these two parents plants.
- **Guayule** [*Parthenium argentatum* (Fam-Asteraceae), commonly known as carrot grass or congress grass] – This is native of America and nowadays it is most troublesome terrestrial weed in India and is present in almost all states of India. The roots of this plant secrete transcinnamic acid, which inhibits the growth of other plants (allelopathy). This is shrub and can grow on poor desert soils.
- **Subabul or Leucaena** [*Leucaena leucocephala* (Fam-leguminosae)] is a fast growing small tree and is native of Central America. This plant is nowadays being planted on a large scale under social forestry. These plants are used as wind breaks, fire breaks, wood as fuel timber etc.
- **Jojoba** (*Simmondsia chinensis*) is a shrub, which is native of Mexican deserts. It is important drought desert plant and hence is being grown in deserts. The seeds of this plants contain about 50% liquid wax, which is similar to sperms whale oil (spermaceti). This liquid wax was originally used in cosmetics, but now is also being used in high performance lubricants.
- **Winged bean** [*Psophocarpus tetragonolobus* (Fam- leguminosae)] is a herbaceous plant, which has capacity of nitrogen fixation. This plant can be used as a green manure plant, fodder plant and also as a cover crop.
- Some potential **oil yielding plants** are there, which provide edible and non-edible oils after suitable treatments. They are – Margosa or Neem, Mahua, Sal, Mustard tree etc.
- **Fodder trees** includes *Acacia nilotica* (Kikar or Babul), *Albizzia lebbeck* (Siris), *Ficus religiosa* (Peepal), *Morus alba* (white mulberry) etc.

Conservation of genetic resources

- It is the conservation of genetic diversities present in different varieties of a species and related species which are likely to be required for improvement of existing crop plants.
- FAO (Food and Agricultural Organisation of UNO) established an International Board for plant Genetic Resources in 1971 with several centres. Two of them are –
  - **IRRI** – International Rice Research Institute, Los Banos, Philippines.
  - **ICRISAT** – International Crops Research

Institute for Semi-Arid Tropics, Hyderabad, India- conserving germplasm of groundnut, pigeon pea, chick pea, pearl millet and sorghum.

Ex-situ conservation

- It is conservation of selected rare plants/animals in places outside their natural homes.
- *Ex-situ* conservation includes offsite collections and gene banks but it is often restricted to channeling the selected organisms into trade for nature lovers, agriculturists and horticulturists.
- *Ginkgo biloba* (ginkgo tree), once in the list of endangered species is now flourishing in gardens.

In situ conservation

- It is maintanance of biological diversity in natural habitats like forests and nature preserves by setting national parks, wildlife sanctuaries and biosphere reserves.

Gene banks

- For plant breeding purpose (*i.e.*, for improvement of plants), large number of varieties with different characters are needed.
- Hence number of plants (both wild and cultivated) are collected and stored at suitable place.
- The place or institution where different plant material (genes) are kept or preserved, is called a **gene bank**. In gene bank, storage is done either in the form of seeds or vegetative materials, but **best and convienent way is storage of seeds**.
- Storage of dry seeds is done at low temperature (–10 to – 20º C), because under these conditions, their metabolic activities are minimum which check their germination.
- Seeds are of **two types** – **orthodox seeds** and **recalcitrant seeds**.
- **Orthodox seeds** are those which are not killed or damaged as a result of decrease in moisture contents and temperature.
- These can even live upto – 196ºC, eg., seeds of wheat, rice, maize, oat, barley (cereals) and also different pulses or legumes.
- **Recalcitrant seeds** are those which are killed or damaged as a result of drying and decrease in temperature.
- These can be stored for a short span, eg., seeds of rubber, tea, coconut, jack fruit, litchi, oil palms etc.
- Conservation of crops with these types of seeds can be made by *In-situ* conservation method and also by tissue culture method.

GENETIC EROSION

- Genetic erosion is the appearance of genes/alleles from the gene pool and reduction in the genetic resources of the earth.
- 20^{th} century has seen a loss of 75% genetic diversity of crop plants.
- By 1990 high yielding varieties had occupied more than 50% areas of wheat and rice lands.
- **Genetic erosion occurs due to** –
  - **Deforestation** – It not only reduces natural population of plants and animals but also causes disappearance of many species.
  - **Crop number** – Originally a large number of plants were exploited for different uses but slowly the number of exploitable plants have decreased. For example, out of 3000 food plant species, only 150 were commercialised. Agriculture is dominated by only 12 species out of which four yield more than 50% of the total (rice, wheat, maize, potato).
  - **Crop varieties** – There is a tendency to incorporate the maximum good qualities in a single variety. As soon as a better variety is developed, the same is distributed far and wide. The older varieties are discarded and their specific alleles lost for ever.

End of the Chapter