ENHANCEMENT IN FOOD PRODUCTION

PLANT BREEDING

Plant breeding? What is mean by plant breeding?

Growing various variety of plants?

Plant breeding is an important and applied branch of Botany which involves collective use of an art and science for changing and-improving the heredity of plants in order to create desired types. It involves the purposeful manipulation of plant species for developing desired plant types that are better suited for cultivation, give better yield and are disease resistant. The other objectives of plant breeding are improvement in the quality, tolerance limits to environmental stresses (like salinity, drought and extreme temperatures), resistance to pathogens and pests. It also helps in development of specific characters of agronomic importance in different crops like dwarfness, intensive branching, reduction in dormancy period etc. Conventional plant breeding has been practiced for thousands of years, since the beginning of human civilization. The recorded evidence of plant breeding dates back to about10,000 years. Many present day crops are the result of domestication in ancient times. Domestication is the process of bringing a species under human management and all our major food crops represent domesticated varieties.

crossing or hybridization of selected pure-lines is done and then artificial selection is made for the plants with desirable traits. Various private commercial companies and government institutions any out plant breeding programm.es In the systematic approach of producing a new genetic variety of a crop.

The five steps in plant breeding are:-

Collection of Variability :-

Variations are the differences seen among individuals of a species or population, for a particular character. Such genetic variations are heritable and are useful in selection. In many crops genetic variations are available as pre-existing characters in wild relatives of the crop. Collection and preservation of all the different wild varieties, species and relatives of cultivated species is done for the exploitation of natural genes available in the populations. All such collected genes are effectively exploited for the breeding programmes. The entire collection (of plants/seeds) having all the diverse alleles for all genes in a particular crop is called germplasm collection.

Evaluation and selection of parents :-

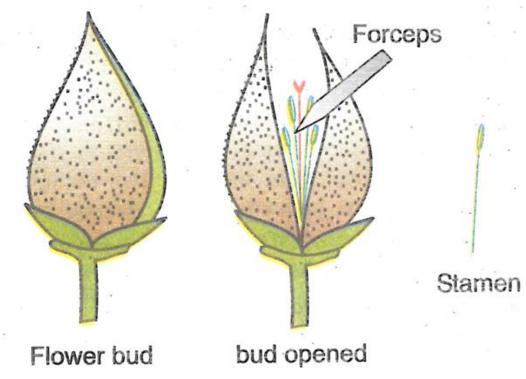
The collected germplasm is now evaluated to identify the plants bearing desirable combination of characters. Such identified plants are selected and then used in the process of hybridization. Purelines are created wherever desirable and possible.

Cross hybridization among the .selected parent:

Hybridization is the crossing of two selected plants differing from each other genotypicaliy in one or more characters, for example high protein quality of one parent and the disease resistance ability of other parent. Through hybridization it is possible to combine useful characters, which are generally scattered in different races or varieties, in a single variety. Hybridization also helps us in exploiting and utilizing the hybrid vigour. Hybrid vigour (heterosis) is the superiority of the hybrid over either parent in one or more characters.

HYBRIDIZATION:

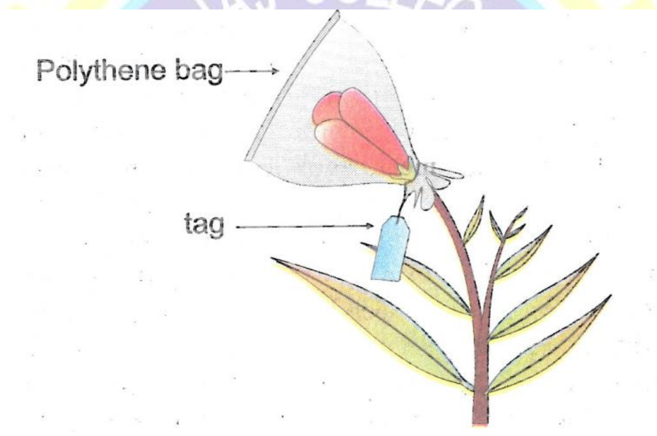
It is a time consuming and tedious process which involves following operations. If a selected plant which has to be used as a female parent, bears bisexual flowers, anthers from its young flower buds are removed. This step is called emasculation. It is not required when selected plant to be used as a female parent, bears unisexual flowers. Emasculated flowers are covered with butter paper bags of suitable size to prevent pollination by pollen grains of unwanted source. This process is called bagging. When the stigma of bagged flowers becomes receptive, matured pollen grains are collected from anthers of selected male parent and are dusted on the stigma of female parent. The female flowers are re-bagged, and the fruits are allowed to develop.



Emasculation (Forceps Method)

Generally only one in few hundred to a thousand crosses, the hybrids formed show the desirable combination of characters.

Emasculation (Hot water method)



Bagging and tagging

Selection and selling of superior recombinants:

The progeny of the hybrids are observed for the desirable combination of characters. Such plants are selected and carefully observed and scientifically evaluated for the success of breeding objective. The plants which are superior to both the parents and exhibit hybrid vigour are collected. Such plants are self pollinated for few successive generations to get homozygosity. Due to this plant attains a state of uniformity and characters do not segregate in the progeny.

Testing, release and commercialization of new cultivars:

The newly selected lines are evaluated for (heir productivity and other agronomic characters like disease resistance, quality of crop etc. In the beginning such evaluation is done by growing these plants in research fields under controlled and ideal conditions of fertilizer application, irrigation, usual crop management practices etc. and their performance ;s recorded. Such plants are then grown in natural fields for atleast three growing seasons in different agroclimatic zones of the country where the crop is usually cultivated, All such tests are carried out by expert agencies like ICAR (Indian Council for Agricultural Research) in India. Variety Release Committee recommends the release of improved variety under new name with the permission of Government.

India has an agriculture based economy, with agriculture accounting for 33% of India's GDP (Gross Domestic Product) and employing more than 60% of the total population. In the post-independence era, the crisis and challenge of supplying enough food to the increasing population with 2 limited suitable agricultural land was the real nerve-wrecker. The development of many improved high yielding varieties of rice and wheat in the decade from 1 960 to 1970 through the techniques of plant bleeding helped the farming community to attain record agriculture production in our country- This achievement was popularly called **"Green Revolution".** The Green Revolution ensured unprecedented surge in the Indian economy and has provided numerous employment opportunities to improve the quality of life. Basic elements considered in green revolution were use of genetically improved varieties for cultivation expansion of usable farmland, cultivation of double crops m the same farmland, optimum use of fertilizers etc.

Some high yielding hybrid crop varieties are Wheat and Rice:

In the history of agriculture, always be remembered because of remarkable increase in wheat production from 11 million tones to 75 million tones and in rice production from 35 million tones to 89.5 million tones. This was due to the development of improved semi-dwarf varieties of wheat and rice. At International centre for Wheat and Maize Improvement in Mexico, the Nobel laurete Norman E. Borlang (Father of green revolution) developed semi-dwarf varieties of wheat. The high yielding and disease resistant 'Semi dwarf varieties like Sonalika and kalyansona were selected and introduced in were selected and introduced in different wheat growing regions of India in 1963. Semidwarf varieties were developed from IR-8, (formed at International Rice Research Institute (IRRI), Philippines) and Taichung Native-1 (from Taiwan). .The derivatives were introduced in India in 1966 and better yielding semidwarf varieties like Jays and Ratna were developed in India.

Some other high yielding varieties in wheat are sonora - 64, Lerma Rojo 64-A, Safed Lerma, Sharbati'-Sonora, etc. while m rice these am Vijaya. Padma, Kanti, and Jayanti.

Sugarcane is cultivated as a primary source of sugar in different parts of world, India is one of the major sugar exporting countries. Sacchorum barberi was commonly cultivated in India but had poor- yield and sugar content. Saccharum officinarum, a tropical species grown in South India had high sugar content and better yield but it did not grow successfully in North India because of its susceptible nature to all serious crop diseases. The hybrid varieties formed after crossing these two species have the desirable combination of characters like high yield, greater sugar content and resistance to most of the crop diseases. These varieties are successfully growing in North India. Some other "improved breeds of sugarcane, developed at the Sugarcane Breeding Institute Coimbatore in India are Co.421, Co.419, Co.205, Co.453, Co.740 etc.

Millets: Millet is a general term for grasses yielding small seeded edible grams- Several hybrid varieties of jowar, bajra and maize have been successfully developed in India Hybridization has resulted in the development of many high yielding varieties which are resistant to diseases and water stress.

Plant Breeding for Disease Resistance

In Topical agricultural regions number of pathogens like fungi, bacteria and viruses cause different diseases to the crop plants and this often results in a significant decrease in crop yield. Such diseases can be controlled by various physical, chemical and biological methods but the most effective, cheapest and convenient method is to produce disease resistant varieties. This not only helps in enhancing the food production but also reduces the dependence on use of' chemical pesticides. It has been studied that the resistance to diseases caused by different pests is genetically controlled character and, therefore, it is possible to transfer these characters to the susceptible and desirable variety through plant breeding techniques. The common crop diseases caused by fungi are brown rust of wheat, red rot of sugarcane and late blight of potato; by bacteria ; and by viruses - tobacco mosaic, turnip mosaic etc.

Methods off breeding for disease resistance:

Breeding is carried out by the conventional breeding techniques of hybridization and selection or by mutation breeding. Hybridization involves similar steps as discussed and these are:- screening germplasm for resistance sources, hybridization off selected parents, selection and evaluation off hybrids followed by testing and release off new varieties. Common crop varieties developed by breeding technique of hybridization and selection for resistance to fungal, bacterial and viral diseases are;

Himgiri of wheat for the disease –

BUM burnt, leaf and stripe rust. Pusa shubhra, Pusa snowball K-l of Cauliflower for the disease Curl blight Mack rot and Black rot. Pusa sadabahar of Chilli for the disease leaf curl and chill mosaic virus.

In different crop varieties and their wild relatives only a limited number of disease resistance genes are present and identified. Therefore, the conventional breeding often prooves to be constrained. Some other methods of breeding for disease resistance are; mutation breeding, genetic engineering, etc.

Mutation can be defined as sudden and heritable variation which appears in organism due to permanent change in their genotype. It is a phenomenon in which alternation of base sequences in DNA is caused and it results in changes in the genotype and phenotype of an organism. Mutations can be induced artificially through chemical or physical factors called Mutagens. Selection of mutant organism is done for the desirable characters. Induction of mutation and its utilization in developing desirable traits in an organism is called mutation breeding. By this method resistant varieties of moong beams to yellow mosaic virus and powdery mildew have been developed.

Plant Breeding for Developing Resistance to Insect Pests

A large scale damage is caused to the crop plants and their products by insect attack and pest infestation. In some crop plants insect resistance may be found due to morphological, biochemical or physiological character. Hairy leaves in some plants are associated with resistance to insect pests. E.g. resistance to jassids in cotton. Smooth leaved and nectar-less cotton varieties are not attacked by the bollworms. Maize variety with high aspartic acid, low nitrogen and sugar content, is not affected by maize stem borers.

Plant breeding for developing resistance to insect pests also involves similar procedure and steps which are used for developing any other agronomic character. Some improved insect pest resistant varieties produced by hybridisation and selection are;

In Brassica: (rapeseed mustard) variety

" Pusa Gaurav" is resistant to aphids.

In Okra (Bhindi): variety "Pusa Sawni" and Pusa A-4 to shoot and fruit borer.

Plant Breeding for Improved Food Quality More than 850 million people in the world have to struggle hard to meet their daily nutritional requirements. A far greater number of people suffer from protein, vitamin and micronutrients deficiency or "hidden hunger" because they are unable to afford the required fruits, vegetables, fish and meat. The diet, without proper contents of micronutrients like iron, vitamin-A, iodine and zinc, makes the people susceptible to diseases, reduces the average life span and also reduces mental abilities.

Biofortification

It is a method of breeding crops to increase their nutritional value. Biofortification differs from ordinary fortification because it focuses on making plant foods more nutritious as the plants are growing, rather than having nutrients added to the. foods when they are being processed. This is an improvement on ordinary fortification when it comes to providing nutrients for the rural poor, who rarely have access to commercially fortified foods. As such, biofortification is seen as an upcoming strategy for dealing with deficiencies of micronutrients in the developing world. There are two main methods:

Selective breeding

plant breeders search seed or germplasm banks for existing varieties of crops which are naturally high in nutrients. They then crossbreed these high-nutrient varieties with high-yielding varieties of crops, to provide a seed with high yields and increased nutritional value. Crops must be bred with sufficient amounts of nutrients to have a measurable positive impact on human health. They must be developed with the involvement of nutritionists and should have extra nutrients, as storage, processing, and cooking of the food affect their available nutrient levels. This method is prevalent at present, as it is quicker, cheaper, and less controversial than genetically engineered crops.

Breeding crops with high value of vitamins and minerals, or higher protein and healthier fats -is the most practical means to improve public health.

The objectives of breeding for nutritional quality are :

improvement in protein content and quality, oil content and quality, vitamin content, micronutrient and mineral content.

Hybrid maize with almost double the quantity of amino acids like lysine and tryptophan has been developed.

Wheat variety, Atlas-66, with high protein content, has been used as a donor for improving cultivated wheat. Rice variety with five times more iron has been developed.

Vitamin-A enriched carrots, spinach, pumpkin; Vitamin-C enriched bittergourd, bathua, mustard, tomato; iron and calcium enriched spinach; protein enriched beans and garden peas have been developed at Indian Agricultural Research Institute (JARI), New Delhi.

Genetic modification

Golden rice is an example of a GM crop developed for its nutritional value. Golden rice contains genes from the soil bacterium Erwinia and either maize or daffodil plants. These genes inserted in the rice genome produce the enzymes necessary for tine synthesis of beta-carotene i.e. provitamin A, which can be converted by the human body into vitamin A. This can help to overcome disorders due to vitamin A deficiency.

The rural poor commonly consume staple crops such as rice, wheat and maize, which are low in micronutrients. Increasing tine micronutrient levels in staple crops can help prevent and reduce the micronutrient deficiencies.

Biofortification is also fairly cost effective. After an initial large research investment - where seeds can be distributed, the "implementation costs [of growing biofortified foods] are nil or negligible", as compared to supplementation, which is expensive and requires continued financing. Research on this approach is being undertaken internationally, with major efforts ongoing in Brazil, China and India.

TISSUE CULTURE:

Tissue culture is another technology, which helps to keep pace **with** increasing food demand and to provide sufficiently fast and efficient systems for crop improvement.

Cellular totipotency; The ability of a single plant cell to divide and differentiate into a mature plant if placed in the appropriate environment is called cellular totipotency.

Plant tissue culture is invaluable when traditional plant breeding cannot generate plants with desired traits.

The culturing or growing isolated protoplasts or cells or tissue or organ on nutrient medium under controlled aseptic conditions to produce complete plant or plant parts is called tissue culture technique5.

Haberlandt (1902) was the first to demonstrate the totipotency and introduce plant tissue culture. It is essential for us to know some important terms used commonly in tissue culture technology.

Terminology used:

Explant:

It is a tissue or part excised from the plant for tissue culture. Parenchyma tissue from root, stem, tubers or the shoot meristem is generally used as explants.

callus

It is produced due to growth of the explant and can be defined as 'an unorganized mass of loosely arranged parenchyma cells'.

Morphogenesis or Organogenesis;

Theprocess of development of different organs such as root, stem, leaves etc. from the callus is called organogenesis.

Clones:

The genetically identical organisms produced from the original parent organism are described as clones of each other.

Requirements of tissue culture technique:

The basic and essential requirements for tissue culture experiments are

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- **Plant material from which the explant is-taken.**
- **Specialized nutrient or culture medium according to requirement.**
- **Aseptic laboratory conditions.**
- **Facility to control different factors such as temperature, light, humidity, etc.**

Different growth factors such as auxins, cytokinins, etc.

Nutrient or Culture medium used: The culture medium used for the experiment may be liquid or semi solid according to the need. The medium is generally supplied with various ratios and concentrations of organic and inorganic nutrients, certain vitamins, sucrose, and plant growth hormones such as auxin and cytokinin. For solid or semisolid medium agar-agar (actually a polysaccharide), a solidifying agent obtained from red algae is used. The pH of the medium is adjusted between 5 - 5.8.

Haberlandt had used a medium with Knop5s salt solution and sucrose. Now use of MS medium (Murashige and Skoog) is more common.

Sterilization: In tissue culture technique, different apparatus, medium used and the explant also is to be properly sterilized to avoid the contamination due to which the experiment may fail. The methods used for sterilization may be dry or wet sterilization, Alcohol sterilization etc. The explants used can be sterilized by using 1% sodium hypochloride or 70% ethyl alcohol or 10% hydrogen peroxide.

Methodology of Tissue culture:

Proper explant is excised from the plant which may be a cell, tissue or apiece of plant organ. Generally parenchyma tissue or meristem is used as explants. It is sterilized properly and placed on solid nutrient medium. The cells from explant absorb nutrients and start multiplying.

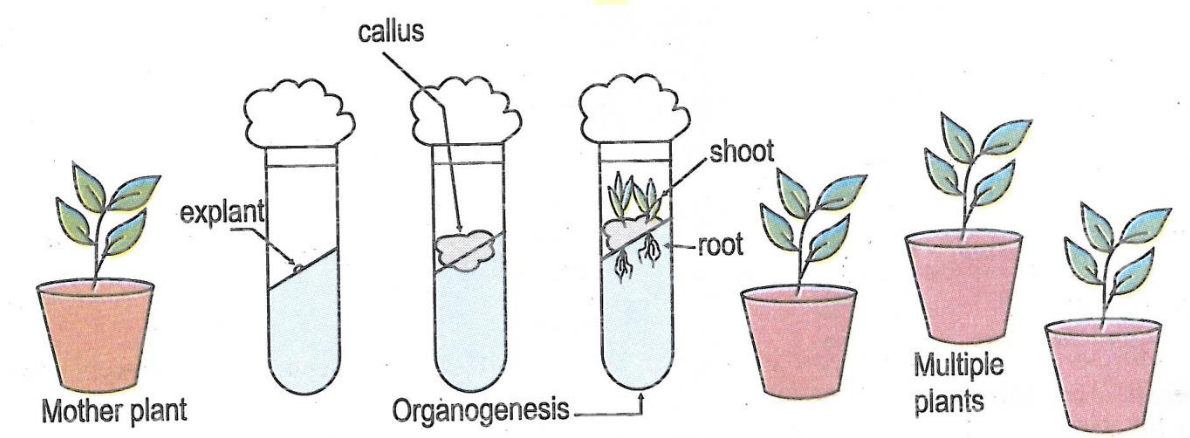
Callus formation and its culture: The callus is unorganized mass of cells produced due to growth of the explant. Generally it has thin walled living parenchyma cells. It develops due to proliferation of cells from explants. All the cells of callus are identical because 'they are produced by mitosis only.

Organogenesis; Now the growth hormoneslike auxins and cytokinins in proper proportion are provided to the callus to induce formation of organs. If auxins are more, roots are formed (rhizogenesis) and if the cytokinins are in more quantity then the shoot system begins to develop (caulogenesis).

Formation of cell or suspension culture: For formation of cell or suspension culture the callus can be transferred to liquid nutrient medium and it is agitated. Due to this the cells from callus get separated. This cell culture is to be agitated constantly at 100-250 rpm. The agitation serves the purpose of aeration, mixing of medium and prevents the aggregation of cells. However, generally the suspension culture shows high proportion of single isolated cells and also small clumps of cells. Suspenion culture grows much faster than callus culture. They need to be sub-cultured every week.

The cell or suspension culture has some advantages as -

The cells can be cultured on larger scale. The suspension culture is more or less homogenous and the cells present in the culture do not show much



Organogenesis- - Steps in plant tissue culture (Callus culture)

differentiation. It is easier to use for subculturing. by the callus and suspension culture we can achieve cell biomass production which can be utilized for biochemical isolation, regeneration of new plantlets, formation of transgenic plants and protoplast culture.

Applications of Tissue Culture:

It is a type of tissue culture technique by which large number of plant propagules are produced. For this, the shoot apical meristem is used as explants. Using the tissue culture technique and adjusting properly the growth hormones, many shoot apices (apical buds) can be produced. These shoot apices are called micropropagules. These are genetically identical and from them new individual plants can be obtained.

Micropropagation technique is useful for obtaining large number of genetically identical plants (clones) within short time period. Due to micropropagation, multiplication of plants becomes season independent. Rare plants can be conserved by this technique. Storage becomes easy as micropropagules require little -space. Commercial production of potato, banana, orchids-etc. is possible.

Production of disease free plants: Tissue culture technique is used to recover the healthy plants from diseased plants. When apical meristems are used as explant, the plants produced are disease free. This is because, in the plants, the apical meristem is generally free from the Infection, i.e. without pathogens like viruses. Good variety of banana, potato and sugarcane is successfully recovered by culturing apical meristem.

Production of secondary metabolites: Many useful secondary metabolites can be producedby cell or suspension culture. These may bealkaloids, allergens, anti tumor agents, enzymes,hormones etc.

Plant	**Product**
Catharanthus roseus	vincristin, Vinblastin
Daucus carota	Anthocyanin
Datura stramoneum	Tropane
Mentha piperata	Menthol
Nicotiana tabacum	Nicotine

Somatic Hybridization: The protoplast fromtwo different plants can be made to fuse by using fusogenic agent as poly ethylene glycol (PEG). From the resultant combined protoplast by tissue culture, a new plant variety can be produced, such as

Potato + Tomato = Pomato

Raphanus + Brassica = Raphanobrassica

SINGLE CELL-PROTEIN (SCP):

Population of human beings and animals is growing ^ a very rapid rate, so the conventional agricultural production of cereals, pulses, vegetables, fruits etc. may not be enough to meet with the food requirements of such a huge population In future. Similarly, the shift of vegeterians to meat-diet has also increased the demand for cereals because to produce 1 kg. of meat by animal farming about 3 to 10 kg. of grains are required- Moreover, a substantial part of human population is also suffering from malnutrition or protein deficiency. One of the best alternative source of proteins for human and animal nutrition is single cell protein (SCP).

"Single Cell Protein (SCP) refers to any microbial biomass produced by uni and multicellular micro-organisms and can be used as food or feed additives." Microbes like Chlorella (green algae), Spirulina (BGA), Methylophilus methylotropus (bacteria) etc. are grown on large scale as source of good protein. Spirulina can easily be grown on waste water from potato processing unit, straw, molasses, animal manure etc. to produce a large amount of biomass. This cm be used as a good source of food rich in proteins, minerals, vitamins, fats and carbohydrates. In this process no kind of environmental pollution is caused. SCP production can be done throughout the year very effectively in a small area of land. Some SCPs are acting as a rich source of Vitamin-B complex. It is also interesting to note that a 250 kg. cow produces 200 g of protein per day but in the same period 250g. of a microbe like Methylophilus methylotrophus can produce 25 tonnes of protein because of its rapid growth, reproduction and high rate of biomass production. SCP can be used as a food for human beings or as a feed for animals like chickens and calves. Thus it can be an ideal supplement to conventional food.