CLASS – 12

BIOLOGY

Chapter – 3

STRATEGIES FOR ENHANCEMENT OF FOOD PRODUCTION

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Strategies for Enhancement in food production

- World population is increased geometrically and food production has increased tremendously in last 2-3 decades but it was not able to keep pace with increasing population.
- Agriculture depends on ***rainfall or irrigation facilities*** and on ***environmental factor*** (*i.e. drought floods, salinity and alkalinity) which contribute the devastation of crop and poor yields*).
- By Applying the biological principal the food production is being increased with the help of ***animal husbandry, plant breeding, newer technique like embryo transfer technology and tissue culture technique*** have brought about revolutionary increases in food production along with improvement in quality.

Animal husbandry

- It is agriculture practice of ***breeding and raising livestock or domestic animals***.
- It deals with art management including proper ***feeding, breeding, health care and shelter of live stock***.
- Live stock animal include ***cattle, sheep, camel, pig, horses goat etc, poultry fisheries*** (*raring, catching and selling of fishes and crustacean like prawn, crabs etc*) and ***apiculture*** *(i.e. maintenance of hives and honey bee for commercial production of honey and wax*).

Advantages of animal husbandry:

1. ***Increase milk production*** through cattle farming.
2. ***Increased production of egg*** though poultry farming.
3. ***Improved quality of meat*** through fish farming.

4. ***Production of honey and wax*** through bee keeping.

Cattle Farming or Dairy Farm Management

- It is management of animal for milk and its production for human consumption.
- In dairy technology scientific approach and methodology are used for:

1. ***Rearing, managing and breeding of dairy animals***

2. ***Collection and processing of milk and its products***.

- the rise of milk production in India has been due to operation flood and white revolution undertaken by:

1) ***National dairy research institute (NDRIs)***

2) ***National dairy development board (NDDB)***

3) ***National dairy corporation (NDC)***

- To increase the production of milk the cross breeding programmers are being under taken in which indigenous breed are crossed with exotic breed to produce ***improved cross breed*** (*viz. for high milk yield capacity, longer lactation period, reproduction period, nutritional requirement, tolerance to climatic condition, resistance to disease etc*).

Breed of cattle

- There are 30 popular breed of cows in India which are classified into 3 main categories:

Draught breeds	**Dairy breeds**	**Dual purpose breed**
These are strong and beast of burden.	These are high milk yielders.	These are dual purpose i.e. yield good milk and also used as drought work.
Example: *Malvi, Nageri*	**Example:** *Red Sindhi, Gir, Sahiwal*	**Example:** *Dangi, Deoni, Haryana*

Variety of dairy cows		
Indigenous breeds (Indian Breed)	**Exotic breeds (foreign breed)**	**Cross breeds (cross between indigenous and exotic)**
Example: *Red Sindhi, Sahiwal, Hallikan, Zebu, Nageri and Gir etc.*	**Example:** *Holstein friesian, Brown swiss, Rade dame and Ayrshire*	**Example:** *Karan swiss, Karan fries etc.*

Food requirement of animals

- The repaired animal feed consist of two main parts:

1. **Roughage:** contain high fiber, coarse and low nutrient material.

   Example: Green fodder, silage, hay, straw material and legumes (i.e. berseen).

2. **Concentrated:** low I fiber and high nutrients value.

Example: *grain of maize, oats, barley, jowar, and by products (i.e. wheat bran, rice bran, gram husk, oil and seed cakes and molasses)*.

Average daily requirement of a cow:

1. *Roughage 15-20 Kg*
2. *Concentrate 4-5 Kg*
3. *Water 30-35 Kg*
4. *Certain additive – antibiotics, minerals and hormones.*

Measure taken in dairy farm management

- Measure taken in dairy farm management for yield and quality of milk are:

1. Selection of good breeds having high yield potential combined with resistance to disease in vital.
2. Providing facilities for housing, water, stringent, cleanliness and hygiene
3. Cattle should be healthy and disease free.
4. Regular inspection and proper record keeping.
5. Regular visit by a veterinary doctor has to bee mandatory.

Disease of cattle

- It can be broadly classified into 3 categories:

1. **Parasitic:** parasite of cattle may be **external** (***i.e. ticks and mites live on the skin***) and internal (*worms affect stomach and flukes damage the liver*).
2. **Infectionous disease:** mainly caused by *bacteria and viruses* like ***foot and mouth disease, anthrax, rinderpest or cattle plague, hemorrhagic septicemia, black quarter and cow pox***.
3. **Non-infectionous disease**: occurs due to ***malfunctioning any body organ*** like liver or stomach etc.

Poultry farming

- It deals with ***rearing of domesticated fowls, ducts, turkey*** for their egg and meat.
- Poultry birds are easy to raise because they can be acclimatized to wide range of climatic conditions.

Important term related to poultry:

- **Broilers:** poultry birds exclusively grown for meat are called broilers.
- **Layers:** female fowls which are mainly raised for egg production.
- **Cockerel:** young male fowl
- **Rooster:** mature male fowl.
- **White leghorn**: most common poultry bird with average egg output of 240 per year.

Poultry breed

- There are three main type of poultry breed in India:

1. **Indigenous breed:**

- There are 3 pure breed of indigenous fouls of which ***Aseel*** or Indian is most popular *(i.e. used to cock fight, provide high yield of mean but not good egg layers*).
- Aseel breed have no. of varieties of which most popular are *Peela, Yakub, Nurie and Kagar*

2. **Exotic breeds:**

- There two most popular exotic breed used in our country is: ***White leghorn, Rhode Island Red***.

3. ***Cross breed : HH260, IBL-80 and B-77***

Poultry farm management

- Selection of disease free and suitable breeds.
- Nutritious feed and uncontaminated water.
- Hygienic conditions at poultry farm.
- Health care of fowl (birds) by sparing disinfectants at regular intervals.
- By timely vaccination against infectious diseases.

Disease in the poultry birds

- Cause of diseases of diseases in the poultry birds are:

1. *Overcrowding*

2. *Unhygienic conditions*
3. *Dampness*
4. *Insufficient light*
5. *Polluted air.*

Viral disease: *bird flu, Ranikhet, fowl fox, marck diseae, hepatities*.

Bacterial disease: *fowl cholera, salmonellosis, coryza*.

Animal breeding

- It aims ***to improving the genotypes of domesticated animals*** to make them useful to humans or ***increasing the yield of animal produce*** and also improving the desirable quantities of the produce.

Objectives of animal breeding are:

1. *Improved growth rate of animals.*
2. *Increased production of milk, meat, and eggs.*
3. *Improved resistance to various diseases.*
4. *Increases reproduction rate.*
5. *Increased productive life*.

Approaches of animal breeding are:

1. Inbreeding
2. Out breeding

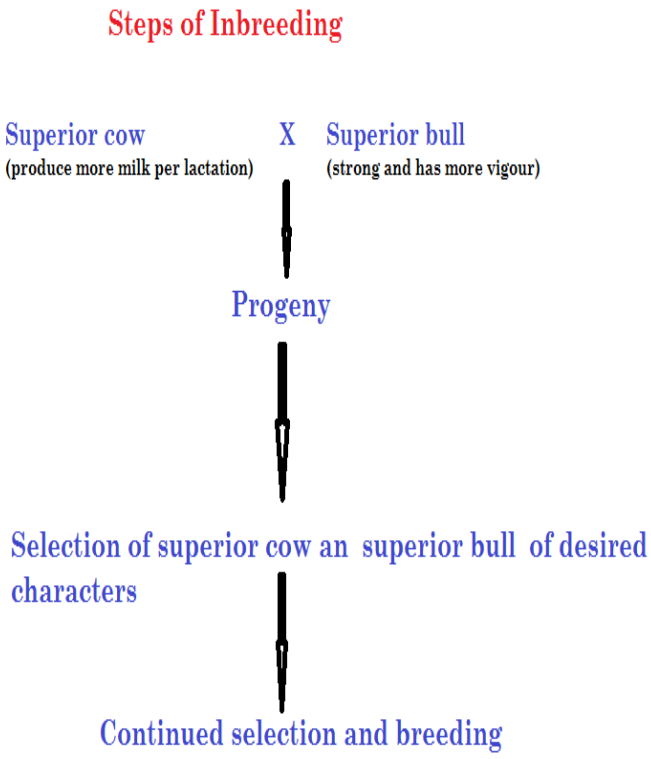
a) Out crossing

b) Cross breeding

c) Inter-specific hybridization.

Inbreeding

- *Mating of more closely related animals of the same bred for 4-6 generation*.
- In inbreeding: mating occurs between **superior males** (*i.e. more vigorous and sturdy*) and superior female (*i.e. that produce more mil per lactation*).



- It is useful in ***obtaining pureline or increases homozygosity*** *(i.e. accumulation of superior genes in homozygous individuals or animals*) and elimination of harmful gene by selection though successive generations.
- Continuous inbreeding cause ***inbreeding depression*** *(i.e. reduced fertility and productivity*).
- To overcome with inbreeding depression mating should be done in between the selected animal of the population and unrelated animal of same breed or of a different breed after few generations.

***Inbreeding is only the method to maintain purity of generation through homozygosity.***

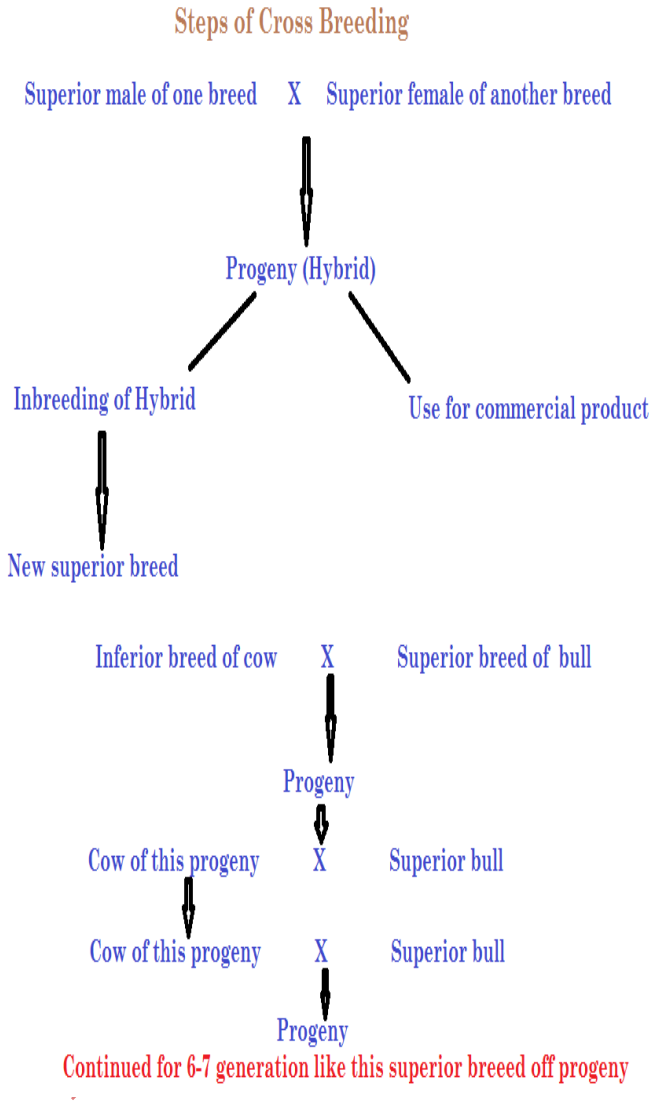
Out Breeding

- It is breeding *of unrelated animal either between the individual of the same breed having different ancestors or between different breeds or different species.*

- It could be classified into three subtype based on mating:

1. **Cross breeding:**

- Mating between *superior male of one breed with superior female of another breed* which allow to combined the desirable qualities of two different breeds into a single breed and results a hybrid.
- It is used to improve the ***existing inferior breeds of cows***.



2. **Out-crossing:**

- Mating of *individual within the same breed without common ancestor on either side of their pedigree up to 4-6 generation*.
- It is best method for animals that are below average in productivity of mil or growth rate and single out cross help to overcome inbreeding depression.

Intra-specific hybridization

- It is ***mating of male and female animals belonging to two different species***.
- Resultant hybrid possess ***desirable feature of both the parents*** having considerable economic value.

Example: *breeding of male donkey with a female horse* produce **mule** (*i.e. sturdier and hardier than parent due to that they are suited for hard work in difficult area like mountain regions*).

Apiculture

- It is maintenance of beehives of honey bees for the production of honey.
- The place where bees are kept is called apirary.
- The advantages for bee-keeping on commercial basis are:

1. ***To obtain honey***
2. ***To obtain products like bees wax*** that is used in cosmetics and polishes royal jelly and bee venom.
3. It needs ***low investment and not involves much labour***.
4. It also ***helps in cross pollination*** as the bee in the field transfer pollen from one flower to another while collecting nectar.

- Various varieties of honey bees are used for bee keeping are:

1. **Indigenous varieties:** *Apis indica, Apis dorsata, Apis florea*

2. **Exotic varieties:** ***Apis mellifera*** (*it has been domesticated in India from Italy to increase yield of honey*).

Colony of honey bees

Queen bee (i.e. diploid fertile female)	**Drone (haploid male)**	**Worker (diploid sterile female)**
It referred as the mother of colony that develop from fertilized eggs and responsible for laying eggs only.	Referred as the males of the colony that develop from unfertilized eggs and responsible for mating with queen only.	Referred as active members of the colony that develop from fertilized eggs and responsible for doing all the jobs of the honey bees.
In each season a queen bee lays up to 2000 eggs.	They remain in the colony to sleep and eat honey till the breeding season.	They cannot reproduce.
It lay fertile egg (i.e. from which workers emergent) and unfertilized eggs (drones emergent)	During breeding season they leave the beehive and mate with the queen and then die	During first half of the life cycle they do indoor duties while second half they do the outdoor duties like collect nectar and pollen like field workers.

Management of high yield of honey:

- Good honey collection capacity.
- Prolific queen production capacity
- Less swarming activity
- Ability to protect itself from enemies

Important aspect of successful bee-keeping

- Knowledge of nature and habits of bees.
- Selection of suitable location for keeping the beehives.
- Catching and hiving of swarms (group of bees).
- Management of beehives during different seasons.
- Handling and collection of honey and bee wax.

Plant breeding

- A specialized technology that based on genetics ***to produce new crops superior to their existing ones***.

OR

It is a practice in which a plant species is ***altered genotypically in ordered to obtain desired changes*** with respect to better yields, disease resistance and more nutritive value.

- In ***conventional plant bree***ding involve crossing or hybridization of pure lines that followed by artificial selection to produce plant with desirable traits.
- ***Modern plant breeding*** make the use of advancements in the field of genetic, molecular biology and tissue culture too incorporate the characters into crop plants:

1. ***Crop yield and improved quality***
2. ***Increased tolerance to environmental stresses (i.e. salinity, drought, extreme temperature)***
3. ***Resistance to pathogens (fungi, viruses and bacteria)***
4. ***Increased tolerance too insect pests***.

Objective of plant breeding

- The primary objective of the plant breeding is to produce improved varieties (i.e. superior to the other exiting varieties of the same crop in one or more desirable characters.
- These desirable traits that should be improved are:

1. **Increased yield** *(i.e. production of high yielding varieties or HYV that improve the productivity of economic produce*).
2. **Improved quality** (*i.e. baking quality of wheat, protein quality in pulses, oil quality in oil seeds*).
3. Increased **tolerance to biotic** *(insect, nematode and microorganism)* and **abiotic factors** (*drought, salinity, heat, cold, frost etc*).
4. **Early and uniform maturity** *(i.e. developing a short duration varieties instead of traditional long duration varieties*).
5. **Crop with desired economic trait** (*i.e. tall plant with profuse branching and high tillering for fodder crop and dwarf variety with short maturation period for cereal crop*).
6. **Wider adaptability** (*i.e. the environmental condition like weather, soil or temperature keep on changing so we have need to develop crop varieties that can withstand and have a wider adaptability to the environmental condition and reduce the risk of crop failure due to change in environment*).
7. **Resistance to pathogen** (*i.e. it should be resistance to pathogens lie viruses, fungi, and bacteria that cause diseases*)

Architect of Green Revolution

- Professor M S Swaminathan is known as the architect of Green Revolution in India.
- Green revolution mainly depended on plant breeding techniques for high yielding and disease resistance varieties in wheat, rice and maize etc.

Steps in Breeding

- Main steps that followed worldwide by government institutions and commercial companies to develop improve genetic varieties are:

1. collection of variability or germplasm collection
2. Evaluation and selection of parents from germplasm.
3. Cross hybridization among selected parents.
4. Selection and testing of superior recombinants.
5. Testing release and commercialization of new variety.

Collection of variability (Germplasm collection)

- For any breeding programme genetic variability is basic root and collection of plant and seeds having all diverse alleles for all the genes in a given crop is called ***germplasm collection***.

OR

Entire collection of plant/seed having all the diverse alleles for all genes in a given crop is called germplasm collection

- ***Germplasm*** of wild plants has tremendous value for the improvement of cultivated crops.

 # germplasm is the sum of all the alleles of genes present in crops and its related species.

Sources of germplasm collection:

- Germplasm can be collected from within country as well as from other countries.

1. Wild species related to crop species.
2. Old local and desi varieties.
3. Cultivated improve varieties.
4. Improved variety which may be no longer in cultivation.
5. Lines produced by plant breeders.

Question: Why a good germplasm collection is essential?

- A good germplasm collection is important to **develop new and improved varieties** which have *resistant to pests, disease and environmental stresses*.
- The germplasm collected to various sources build the **material** (i.e. containing valuable gene) that *help to plant breeder to access to the entire array of genes of a species to develop an improved desired variety* .

Loss of genetic variability or genetic erosion:

- In modern day agriculture the improved varieties are being chosen and cultivated that result **genetic uniformity** (*i.e. old varieties replaced by uniform new varieties*) and number of ***wild varieties that existed before have been damage of wiped off***.
- The loss off wild varieties is called **loss of genetic variability or genetic erosion**.

Conservation of germplasm:

- There are various way for conservation or maintaining the germplasm are:

1. Storing seed and growing periodically in the field to obtain fresh seed (because the percentage of seed germination decreases with storage time).

2. Tissue culture is also help in storing a large number of genotypes in a relatively small area in culture vessels.

Evaluation and selection of parents

- The germplasm evaluated and selection of parent plants with desirable combination of character is done by –
    1. ***Natural selection*** (*i.e. best adaptive variety of a crop survives and rest get wiped out in due course of time*)
    2. ***Artificial*** **selection** (*i.e. better variety of crop can be made artificially from mixed population by man*).
- Selection is based on ***desirable characters from given population*** (i.e. based of phenotypic traits) in which ***desirable character is preserve and undesirable one are eliminated.***

Selection of parent can be done by three types:

1. **Mass selection:**

- It practices in ***naturally cross pollinated crops*** such as **maize.**
- In this ***seed of selected plant are mixed and sown in the same field and best plant (i.e. healthy and disease free) are selected.***
- The seed of selected plant again collected and mixed seed are sown again in same field for many years and obtain **homozygogosity.**
- It prefer because it is the *simplest easiest and quickest method of crop improvement for local and wild varieties, pollination need not to be controlled*.
- It has disadvantaged that there is ***no control over pollination*** which *cause greater heterozygosity and diminish the desirable qualities*.

2. **Pure line selection:**

- It done in mature ***self pollinated crops*** such as *wheat, oat, barley and pea*.
- In this the *seed of selected plant is collected separately and sown in separate rows* and from each row best plant are selected again and separate row are maintain for the seed of individual plant .
- This process repeated for many years to obtain ***homozygosity for desired characters***.
- The homozygous plant population derived from each individual plant is called **pure line** and procedure to obtain is called ***progeny testing or inbred selection***.
- It is only the method to ***improve the local varieties of self pollinated crop*** and the best genotype (i.e. for yield, disease resistance,

insect resistance, earliness, quality etc) can be isolated from mixed population of an old variety.

- It has certain disadvantage like it *take longer time and the extreme homozygosity of pure line result low yield and undesirable characters*.

3. Clone selection:

- It is practiced in ***vegetative propagated plant*** like *sugarcane, banana, potato* etc.
- In this the **clone** is a population of plant that raised from a single vegetative propagated plant .
- This method is helpful in ***conserving hybrid vigour for several generation*** and only ***applicable for vegetatively propagated crops*** because no new genetic variability can be created.

Cross hybridization among the selected parents

- The desire character from two different plant combine to get improved variety (i.e. high protein quality of one parent combine with disease resistance trait of another parent.
- In hybridization crossing of ***two varieties are occur which having desire gene*** (i.e. useful characters) and bring together into new variety (i.e. hybrid).

OR

Cross between ***two individuals or lines differing in genotype***.

- In hybridization the hybrid which forms is superior with compare to parent in one or more traits.
- Depending upon the individual crossed the cross hybridization could be following type:

1. **Intravarital hybridization:** in this crossing occur ***between two different verities of the same species***.
2. **Intra specific hybridization:** cross occur between ***two different related species*** and it has important role to produce disease resistance varieties.
3. **Intragenic hybridization:** in this crossing occur between ***two different genera*** and it is difficult to produce and often sterile progeny produce.

Steps in hybridization

1. *Two healthy plants with desired characters selected* and then ***parent plants are grown separately*** to ***avoid cross pollination***.
2. **Emasculation** (i.e. stamen are removed with fine forceps) is done with ***immature bisexual flower*** to ***avoid the chances of self pollination***.
3. **Bagging:** the ***emasculated flower is covered with a paper bag and tagged with information*** (*i.e. name of the parent plant, time and date of emasculation etc*.) and the bag will be opened when the flower is to be artificially pollinated.
4. **Pollination:** in this the *viable pollen grain are collected and dusted on the mature receptive stigma of emasculated flower*.
5. **After the fertilization** the *seed are collected and shown to obtain F1 plants with desired character* and this cycle of crop raising and selection continues till plant with desire character are obtained.

Selection and testing of superior recombinants

- In this those plant are selected that have desire character combination and are superior with both parents and are self pollinated for several generation to obtain pure line or homozygosity.
- The selection process is crucial to the success of the breeding objective because it need careful scientific evaluation of the progeny or hybrid formed.

Testing release and commercialization of new variety

1. **Testing or evaluation:**

- After the development of improved variety, it undergoes evaluation process for factor like yield, quality, disease and insect's resistance and number of other traits.

1. In India, Indian **council of Agriculture Research (ICAR)** is the evaluating agency which grows the hybrid in the research field and records their performance under ideal fertilizer application, irrigation and other crop management practices.
2. The evaluation of research field is followed by testing the material in farmer's fields for at least ***3 years at several locations in whole country***.
3. For the evaluation the whole country is divided into the ***two agroclimatic zones*** (*on the basis of soil and climatic condition*) and evaluated for three year in each agroclimatic zone where the performance of material is compared with best available existing varieties as well as with other new varieties.

2. **Release of new variety:**

- To release of new varieties a breeder has to go through the following procedure:

1. ***Breeder of new variety has to make a proposal for its release.***
2. ***Breeder proposal is considered by a variety release committee.***
3. ***New variety given a name and release as a new variety if proposal accepted.***
4. ***The government notifies for each new release.***

3. **Commercialization of improved variety:**

- In plant breeding the term seed mean grain of rice, wheat, maize, tuber of potato and stem of sugarcane or any part of the plant that is used for producing new plants.
- The seed that are sold for growing crop must have a proper label carrying information about:

1. ***Purity of seeds***
2. ***Germination percentage***
3. ***Percentage of weeds***
4. ***Certification of validity***
5. ***Kind of seeds***

Crop improvement

Plant breeding for disease resistance:

- Crop plants are attacked by a number of pathogen that affects the yield considerably so it is important to develop the varieties that are resistance to diseases.
- **Resistance** means *ability to prevent the pathogen from causing diseases* and it is *determined by genetic constituents of host plant*.
- **Resistance varieties** help to *increases the yield* and *reduce the dependence on the use of fungicides and bactericides*.
- Before breeding following factors should be known:

a) **Genotype of host:** it can be manipulated and changed by plant breeder and it could be two type:

I. **Susceptible –** this genotype does not have resistance to pathogen.

II. **Resistance –** this genotype does not get the diseases and have resistance to diseases.

b) **Genotype of pathogen:** the genotype of the pathogen keep changing with time and it also found in two strain:

I. **Virulent -** strain cause diseases

II. **Non- virulent –** train does not cause diseases.

c) **Environmental factors (i.e. heat, temperature, moisture etc.) and mode of transmission of pathogen.**

- Development of disease resistance varieties of plant depend upon:

1. Good sources of plant varieties
2. A dependable disease test.

Disease test:

- In this all the plant develop by breeding experiment are grown under condition in which they susceptible to diseases and if the plant does not get diseases that mean it is diseases resistance.

Breeding techniques for disease resistance:

1. *Conventional breeding*
2. *Plant introduction*
3. *Selection*
4. *Grafting*
5. *Mutation breeding*

Mutation Breeding

- **Mutation** is process by which ***genetic variation are created*** through *change in the base sequences within the gene* that results **creation of new character that not found in parental type**.
- **Mutation breeding is** use of *induced mutation in plant breeding techniques to develop improve crop varieties.*
- Mutation can be induced through:

1. **Radiation:** *gamma radiation (i.e. Most common) , X rays, UV rays*
2. **Chemicals:** *nitrous acid, nitro-methyl urea, colchicines, ethylemethane sulphonate (EMS) etc.*

Procedure for mutation breeding:

1. Vegetative propagules (i.e. bulb, corn, rhizome and seed) are treated with suitable mutagen.
2. Propagules along with control set allowed o germinate in petriplate and then transferred to the field.
3. Progeny or seed obtained by self pollination are grow in the another crop season.
4. Plants are carefully observed to identify and select the mutation of interest.
5. Plants with desirable trait or mutant line are isolated and release as new varieties.

Precaution in mutation breeding:

1. *Stability* of mutation should be thoroughly examined because mutations are reversible and mutant gene can revert to the wild stage.
2. In sexually reproducing plant mutation always induced in germinal cells because germinal mutation always transferred to the offspring.

Plant breeding for developing resistance to insect pests

- Development of an insect resistance crop done by plant breeding in which the source of resistance gene are cultivated verities, germplasm collection of domesticated crops or their wild relatives.
- The advantage of developing disease and insect resistance varieties are to minimize the use of chemicals for their control and increase the crop yield and enhance the quality of food.

Crop	Variety	Insect pests
Brassica	Pusa Gaurav	Aphids
Flat bean	Pusa sem 2, Pusa sem 3	Jassids, aphids and fruit borer
Okra (Bhindi)	Pusa Swami Pusa A-4	Shoot and fruit borer

Plant breeding for improvement for food quality (nutritional quality)

- **Biofortification:** is breeding crop good quality crop or edible crop which has nutritional quality.
- **Nutritional quality crop** mean a crop which is suitable for consumption.
- **Edible crop or good quality** crop is crops that contain adequate quality and quantity of nutrients like carbohydrates, protein and oils and also free from antinutritional factors (*i.e. Compound that have adverse or harmful effects on the growth and development of human or animals*).
- With the help of plant breeding numbers of desired nutritional qualities crop are develop :

I. **Protein content and quality:** variety of maize like **Shakti**, **Rattan**, and **Protina** are rich in lysine, wheat variety **Atlas 66 has** high protein content.

II. **Iron fortified rice varieties which** have 5 times more iron than present consumed rice varieties.

III. IARI new Delhi also released number of vegetable crop which are rich in vitamin and minerals like :

i. *Vitamin A enriched carrot, spinach and pumpkin*

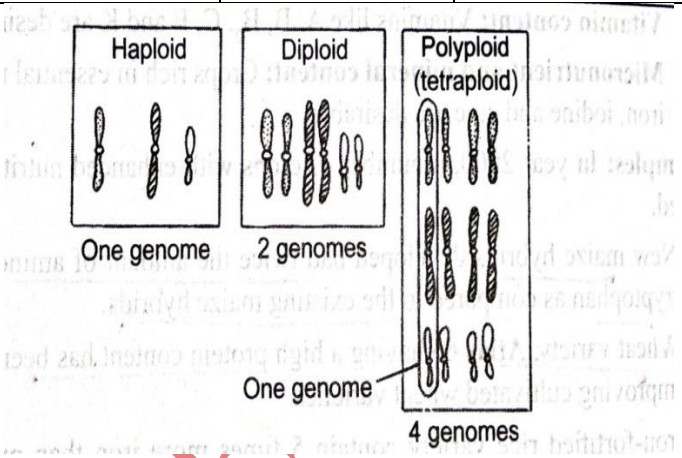
ii. *Iron and calcium enriched spinach and bathua*

iii. *Protein enriched beans – broad, lablab, French and garden peas.*

Polyploidy in crop improvement

- Polyploidy mean ***multiplication of one or more genomes*** are known as polyploidy.
- The organism with more than two set of chromosome is known as polyploid.

Shoot and fruit borer	Type of ploidy	
1	Monoploid or haploid	
2	Diploid	
3	Triploid	**Polyploidy**
4	Tetraploid	
5	Pentaploid	



- Polyploidy in sexually reproducing organism arise due to:

1. *Fertilization of haploid gamete with another gametes containing 2n or more chromosomes*
2. *Failure of separation of chromosome during mitosis (i.e. non-disjunction)*
3. *Failure in meiosis during gamete formation*

- Polyploidy could be of two type :

1. **Autopolyploid**
2. **Allopolyploid**

Autopolyploid:

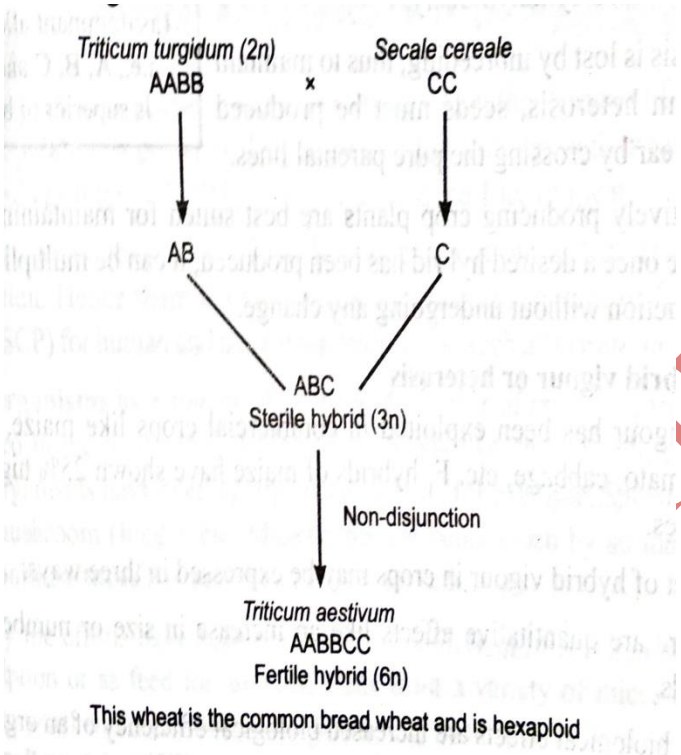
- Occurs naturally many plants but in low frequency and it can be induced in relatively high frequencies by using a mutagen **colchicine** (*i.e. alkaloid drug*) that break or prevents the formation of spindle fibers and arrests the mitosis which results non-disjunction (i.e. no movement of chromatids in anaphase stage) and due to that all the chromatids of the dividing cell are included in the same nucleus.

Example of autopolyploid is potato, ground nuts, and coffee.

Allopolyploid:

- It raise by involving more than one species or genera through multiplication of genome.
- it also occurs in nature but also induced by artificially by:

1. Hybridization of two different species and produce the F1 hybrid (i.e. sterile)
2. The chromosome number of F1 hybrid become double by using colchicine and develops a new fertile species.



- The polyploidy species have greater tolerance for harsh climatic conditions and have high economic value.

Example: *Raphano-brassica, Brassica juncea and triticum vulgare.*

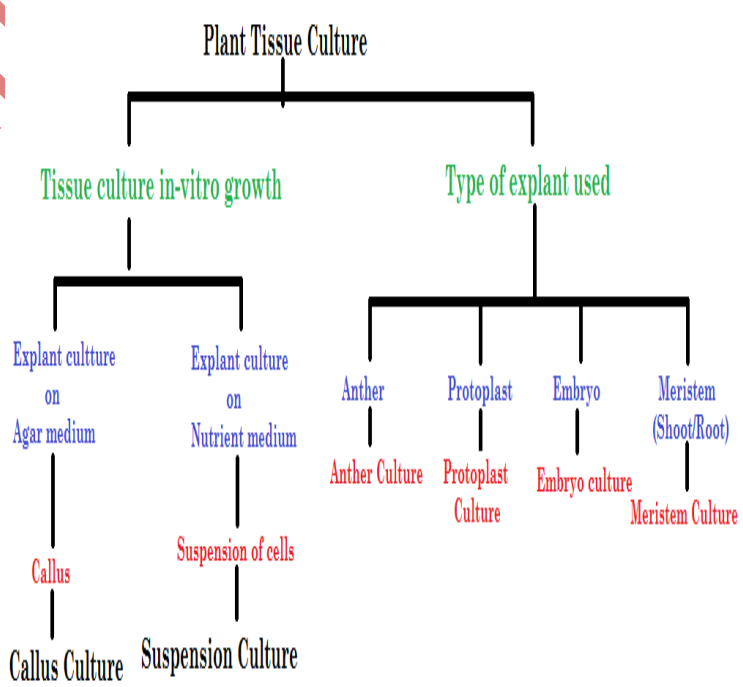
Hybrid vigour (Heterosis)

- *Superiority of hybrid over either parent in one or more traits* is called **hybrid vigour or heterosis**.
- **Heterosis** is lost ***by inbreeding*** and ***maintain by crossing the pure parental lines***.
- Vegetative producing crop plants are best suited for maintaining hybrid vigour.
- Effect of hybrid vigour are expressed in 3 ways:

1. **Quantitative effect:** like increase in size or number of fruits and seed.
2. **Biological effect:** increase the biological efficiency of organism (i.e. capacity of reproduction and ability for survival).
3. **Physiological effect:** resistance to various diseases and early maturation of the plant.

Plant tissue culture

- It is process to maintain and growth of plants cells, tissue and organs in suitable medium in-vitro.
- It is classify by various ways

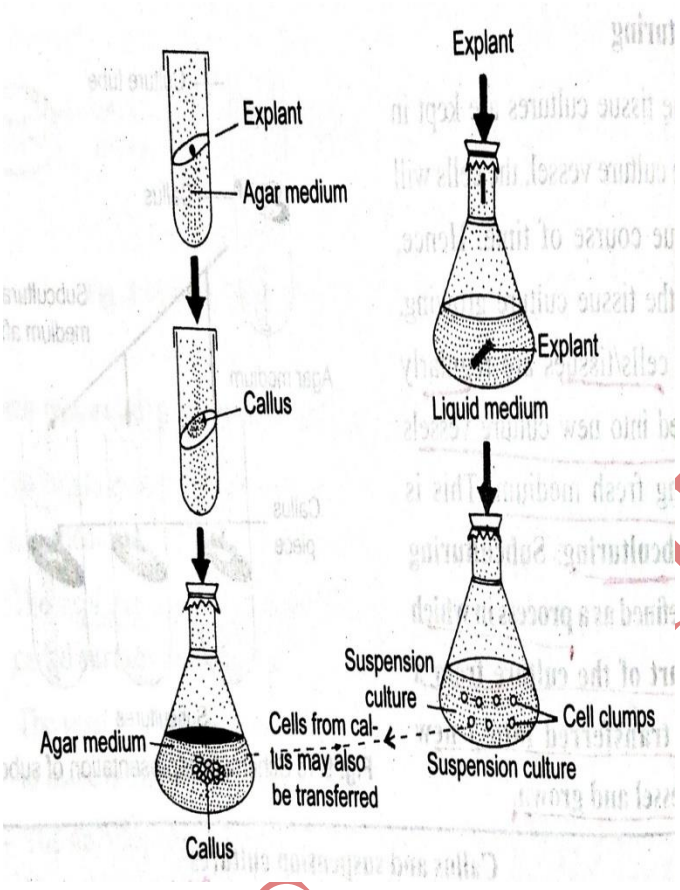


Callus culture:

- Explants (i.e. containing meristem cells) are put in nutrient medium (i.e. containing **Auxine** – 2, 4-D and **Cytokinin** – BAP) on agar **solid medium**.

- Cells grow and form **callus** within 2-3 week and transferred in a growth medium (*i.e. contain a different combination of plant hormone*) and plantlets are obtained through two different routes:

1. *Shoot regeneration followed by rooting of shoot*
2. *Regeneration of somatic embryo followed by germinations.*



Suspension Culture:

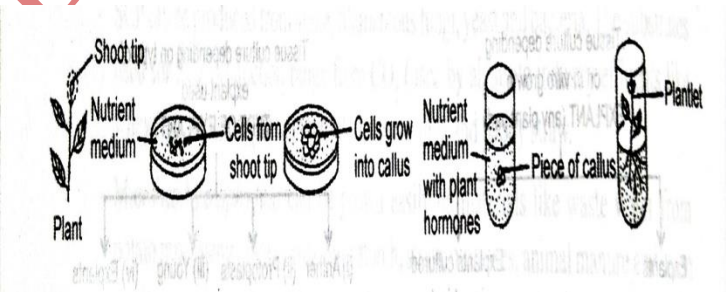
- It involve the growth of single cells in **liquid growth medium** (*usually contain Auxin 2, 4-D*).
- In the suspension culture, growth of cells required constantly ***agitation*** which provide:

1. *Aeration for culture*
2. *Constant mixing of medium*
3. *Breakage of cells aggregates into small group of cells.*

Basic method of Plant tissue culture

1. Small paces of tissue form shoot tip or root tip is taken and grow in a nutrient medium (i.e. contain minerals, vitamin and hormone) under **sterile condition**.
2. **Callus** (i.e. unrecognized mass of cells) is formed.
3. Small part of callus transferred to another medium contains different combination of **plant growth regulator** (*i.e. Auxine and Cytokinens*) to induce ***growth and differentiation***.
4. Cells differentiated into root and shoot and plantlets are formed which is transferred into soil or potted to grow.

Nutrient medium contain: Sucrose (source of energy), Inorganic salts, certain vitamin and amino acid and growth regulators (i.e. hormone).



Condition necessary for successful Plant tissue Culture

1. **Sterile condition** (*i.e. explants culture vessels, media and instrument used should be free from microbe or contamination which followed by the **surface sterilization** and **sterilization** through by stem treatment, dry heat and alcohol*).
2. **Culture media** that provide ***nutrients require for growth and development*** of the explants.
3. **Combination of growth regulator or plant hormone :**

a) **Auxine** – *2,4 dihlorophenoxyacetic acid*

b) **Cytokinins** – *Benzyle aminopurine*

4. **Appropriate temperature**

5. **Sub culturing:** process in which ***a part of culture from vessel is transferred into new culture vessels*** and growth.

Regeneration

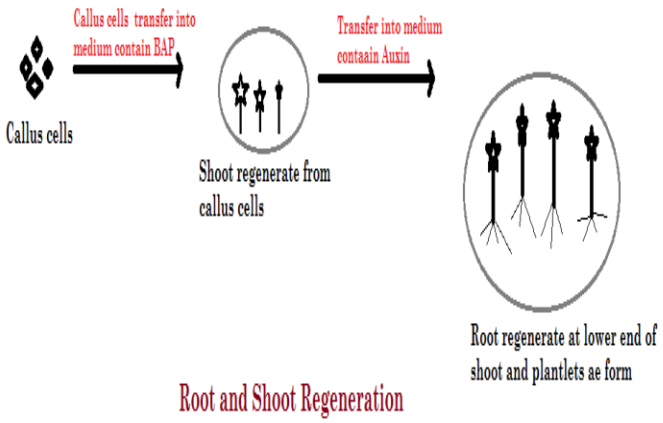
- ***F. C. Steward and his co-worker*** give concept of totipotency in carrot.
- **Totipotency** is *ability of plant cells to give rise a complete plants*.
- Development of organized structure (*i.e. root shoot or somatic embryo*) from culture cells is known as **regeneration**.

1. Shoot and Root Regenerations:

- In this cells transferred into growth medium contain hormone that promote root and shoot regeneration like:

a) **Shoot regeneration : cytokinin – BAP**

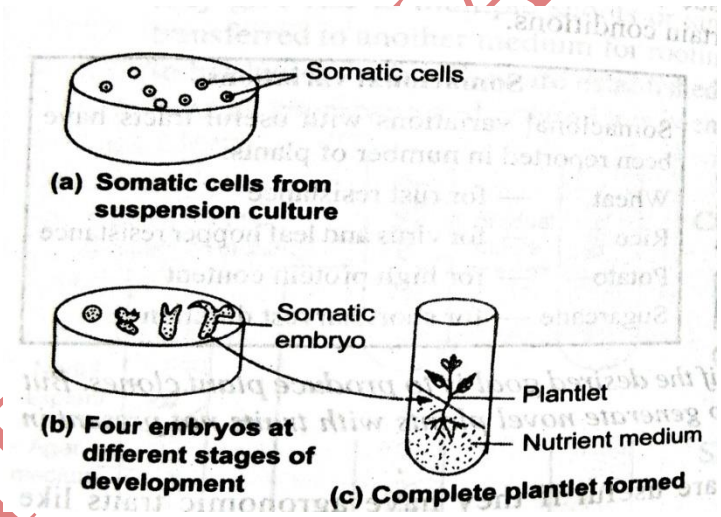
b) **Root regeneration: Auxin – NAA**



Root and Shoot Regeneration

2. Somatic embryo regeneration:

- In this somatic ***embryo develop from single cell and germinate into complete plantlet***.
- ***Suspension culture*** are transferred into a medium contain ***high concentration of 2,4-D*** (*induce culture cells to form individual embryo*)
- Now regeneration of somatic embryo induced by ***high concentration of Auxin*** in which young embryo develops into mature embryo induces by high concentration of Auxin in which young embryo develop into mature embryo into same or another medium.
- The mature embryo isolated and transfer into new growth medium where they grow into individual plants.



Hardening and establishment in the field

- Plantlets are taken from culture medium are delicate and sensitive so before establishing them into filed they undergo hardening process.
- **Hardening makes** plantlets ***to tolerate the relative harsh environment condition outside the culture vessels***.
- During hardening plantlets ***kept under reduced light and high humidity for a suitable period of time*** which makes them ***suitable to grow in the field***.

Application of Tissue culture

- Propagation of a large number of plants in very short duration.
- Rapid somaclonal propagation formed plant which is genetically identical to the original plants.
- Development of transgenic plants by genetic engineering.

Meristem culture

- It helps to raise ***healthy plants which are disease free***.
- In meristematic culture shoot removed as explants and grow in-vitro to obtain disease free plants.
- In meristem culture multiple shoot are formed without callus formation.
- In this shoot and meristem or nodal segments are cultured in medium contain **cytokinins** which promote ***branching by suppressing apical dominance***.

Application:

1. Rapid clone multiplication.
2. Production of disease free plants.
3. Germplasm conservation.

- develop seedling by embryo culture which can produce the whole plants.

Anther culture and haploid production

- It is also called ***production of haploid from anther***.
- Anther is removed from the flower of plant and transferred to an appropriate growth medium in which

1. Haploid nucleus of pollen continues to divide and give a pollen embryo which develops into haploid plant.
2. Some time continued division of pollen nucleus produce callus which grow on a culture medium to regenerate shoot and formation of plantlets.

 # Production of haploid plant from unfertilized ovule is done in India by Guha and Maheshwari in Datura.

Advantage:

- Production of homozygous or pure line through doubling by treating haploid with ***colchicine***

4. Easy to introduce the transgene and produce in large number of transgenic plant.

Embryo culture

- In this ***young embryo excised from developing seed*** and then culture in nutrient media.
- It allow young embryo to complete their development and give rise seedling which can develop into plants.

Application:

- Resource embryo for successful hybridization.
- In some plants seed lack store food (e.g. orchids) so in such case embryo culture in-vitro on nutrient media and allow the formation of seedling.
- In certain species seeds remain dormant due to presence of inhibitors in endosperm so in such case embryo excised from seeds and made to

which results the conversion of sterile haploid plant into fertile diploid plants.

- Halpoid are very useful in mutation breeding because effect of nutrition is expressed into haploid because only one set of chromosome.

Somatic hybridization and protoplast culture

- It is process of ***production of somatic hybrid by fusion of protoplast of selected parents***.
- In somatic hybridization ***protoplast are produce by removal of cell walls with enzyme*** (**cellulase + Pectinase**).
- After that protoplast fusion is induced by ***polyethylene glycol (PEG) or brief high voltage electrical current*** which lead the formation off somatic embryo.

Protoplast culture: in this protoplast are cultured in suitable medium in which they regenrate cell wall around them and start dividing to produce a callus or somatic embryo.

Through this somatic embryo a complete plantlet can be develop in cultures.

Application of somatic hybridization:

- It allows production of hybrid between line and species.

  Example: tomato + potato = Pomato (somatic hybrid)

- It helps in genetic manipulation because it is easy to introduce the foreign DNA or gene.
- It helps to incorporate beneficial trails into another plant belonging to different species.

Single cell protein

- It is microbial mass that rich in high quality protein and obtained from both single and multicellular microorganism.
- Single cell protein can be produce from algae (*Spirulina*), filamentous fungi, yeast and bacteria (*Methylophilus methylotrophus*).

Commercial production of SCP is mostly based on yeast and fungi (*Fusarium graminearum*).

Significance of SCP:

1. SCP is rich in quality protein and poor in fats.
2. It reduces the pressure on agriculture for supply f required protein.
3. It has been calculated that 250 Kg cow produce 200 gm of protein/day while in same period 250gm microorganism like *Methylophilus methylotrophus* produce 25 tons protein.