# Strategies for Enhancement in Food Production

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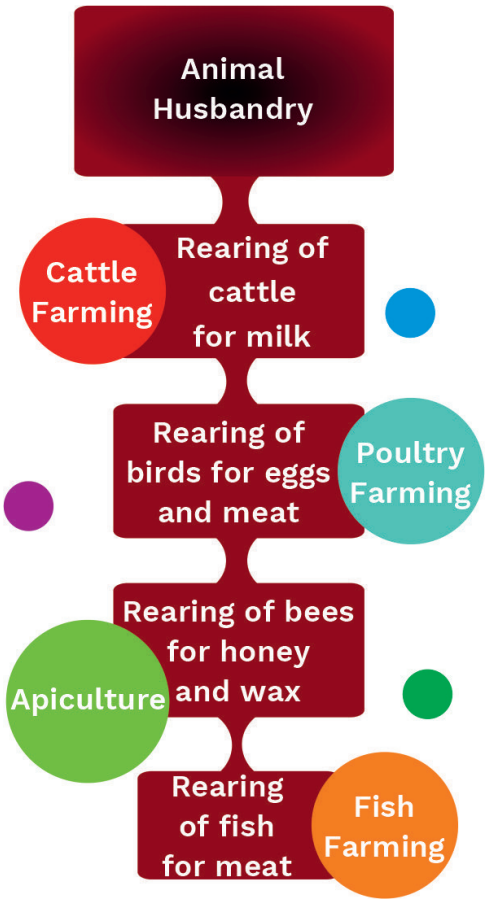
# Strategies for Enhancement in Food Production

**INTRODUCTION**

- Conventional method of breeding was not able to fulfill the nutritional requirement of the world. Thus, the scientists developed new breeding techniques that helped in increasing the productivity and catering to the food requirements of the world.

**ANIMAL HUSBANDRY**

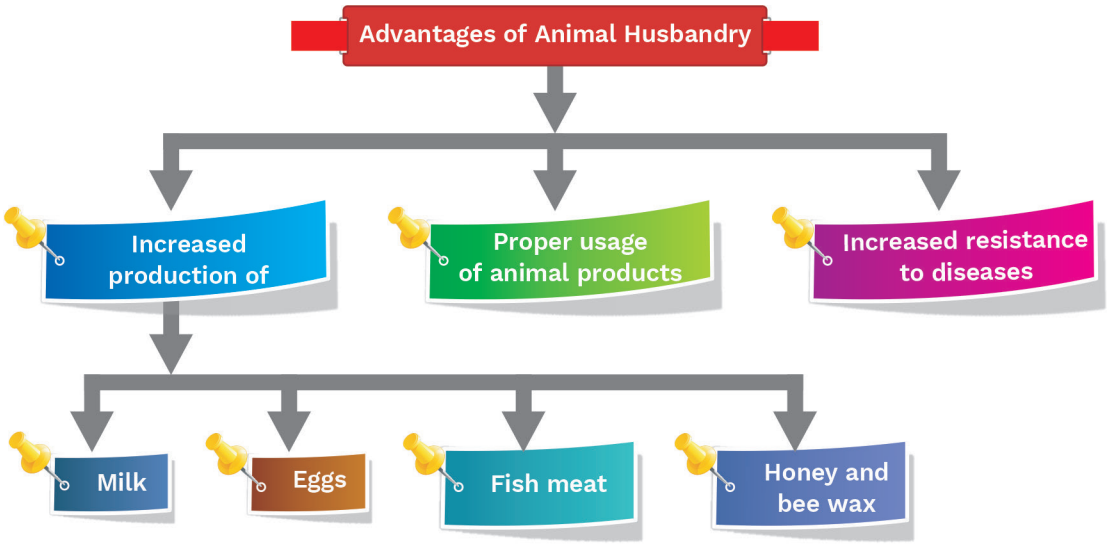
- Animal husbandry deals with the care and breeding of livestock that is useful to human beings.




Modified breeding strategies has increased the food bowl capacity of the world

**Definition**

**Animal Husbandry:** It is the agricultural practice of breeding and raising livestock that is useful to humans.

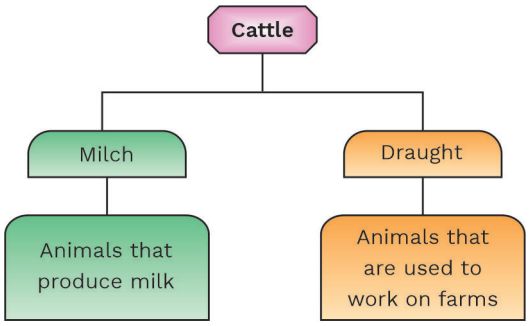



**DAIRY FARM MANAGEMENT**

- Cattle are used for the following:
  - Ploughing the field
  - Driving carts for transportation
  - Providing milk
  - Providing meat
- **Cattle are of two types:**

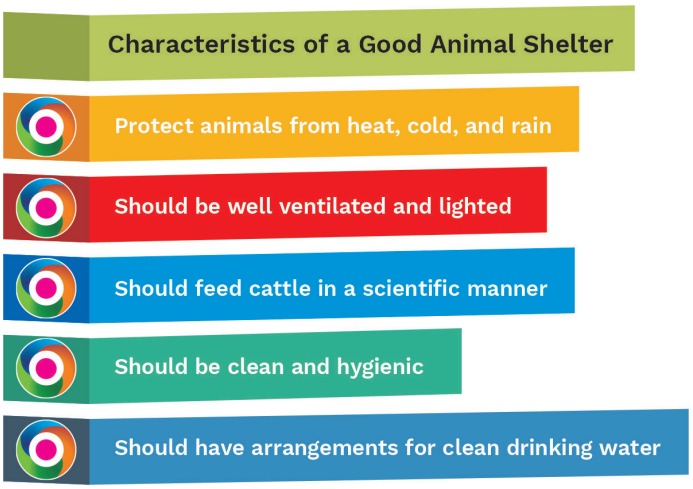
**Definition**

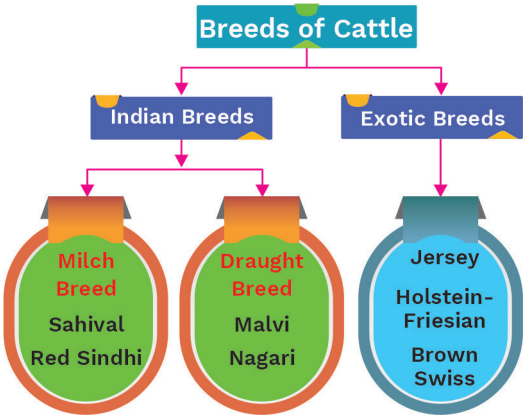
**Dairying:** Dairying is the management of animals for milk and milk products for human consumption.




**Dual Purpose Breed**
Cow milk yield is high while their bullocks are good work animals.
Example: *Kankrej* and *Ongole*

- The cattle are fed and given a balanced feed to keep them healthy.
- Milk yield is dependent primarily on the quality of breeds.
- Breeds having high yielding potential are combined with breed resistant to diseases.



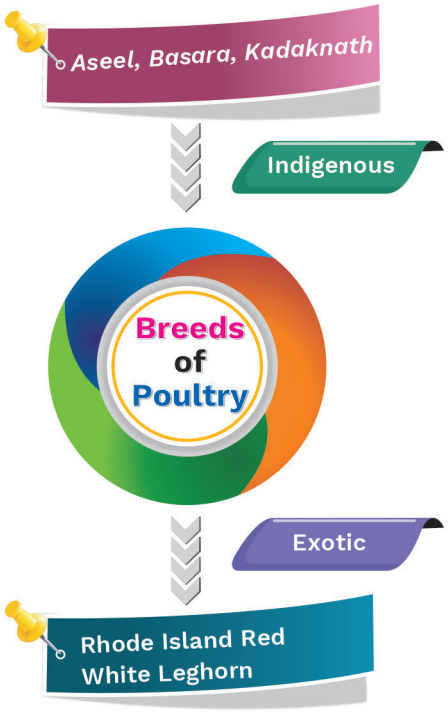



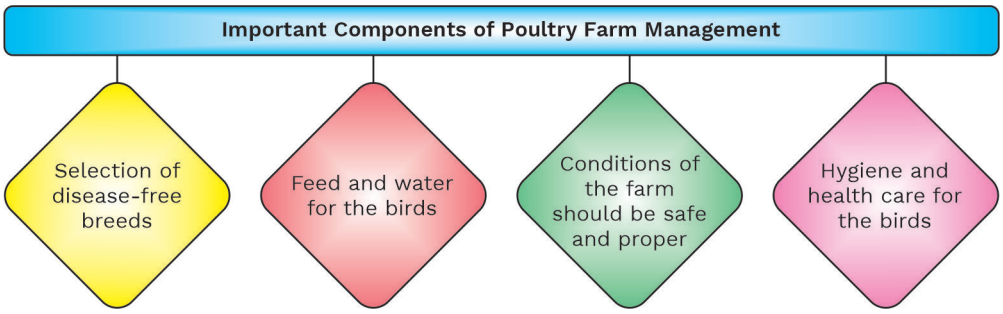

**POULTRY FARM MANAGEMENT**

- Poultry includes chicken and ducks and sometimes turkey and geese.
- The birds are exclusively raised for eggs are known as layers while the birds that are exclusively raised for meat are known as broilers.
- The birds that lay a large number of eggs are crossed with birds having high meat quality or disease resistance to have hybrids with the superior quality.
- Feed involves/comprises of two main components like:
  - **Roughage-**It has large amount of fibres but less nutrients.
    E.g., Hay, fodder grass, Elephant grass
  - **Concentrates-**It is rich in proteins and is easily digestible. It is a mixture of cereals, oil seeds and molasses.
- Besides concentrates and roughage, antibiotics, minerals and hormones are added to the feed.
- The birds are fed on grains, oil cakes and green vegetables. Broilers are also fed with diet rich in proteins and fat with a high amount of Vitamin A and K.

**Definition**

**Poultry:** It is the rearing of birds for their eggs and meat.





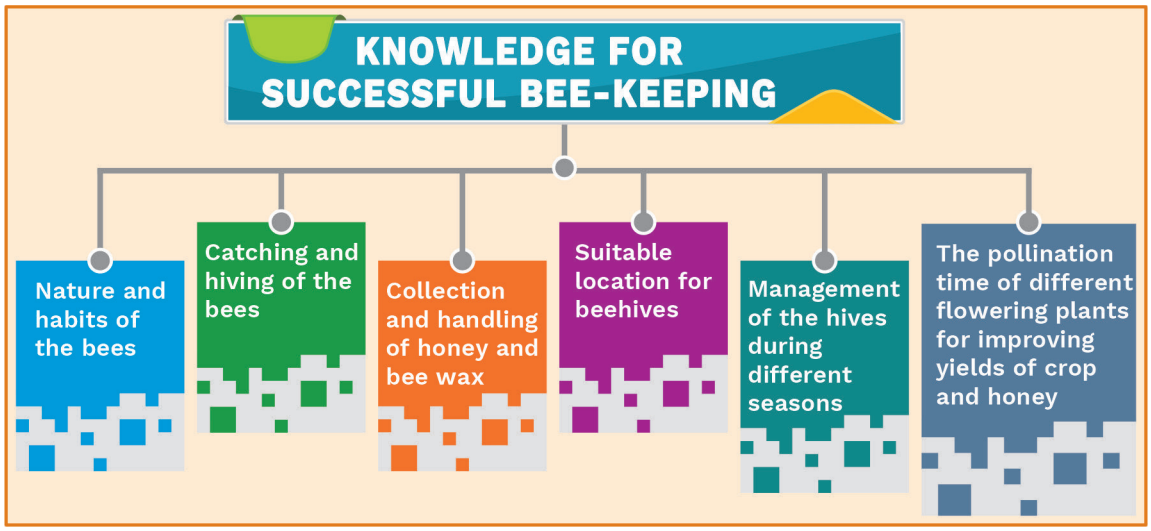

**BEE-KEEPING OR APICULTURE**

- Apiculture is done to produce honey and bee wax.
- Honey is used as:
  - Food
  - Medicine in Ayurveda
  - Bee wax is used for the preparation of cosmetics and polishes.
  - Bee-keeping can be practised in area where there is pasturage i.e. some wild shrubs, cultivated crops, fruit-orchards.
- Different species of honey bees are:
  - *Apis dorsata* – Rock bee or giant bee
  - *Apis indica* – Indian bee,most common species
  - *Apis florea* – Little bee
  - *Apis mellifera* – Italian bee
- *Apis mellifera* is better than the Indian species because of
  - high yield
  - docile nature
  - large egg production
  - less swarming
- Beehives can be kept in
  - courtyard
  - verandah
  - roof of houses
  - places where an abundance of bee flora is available.

**Definition**

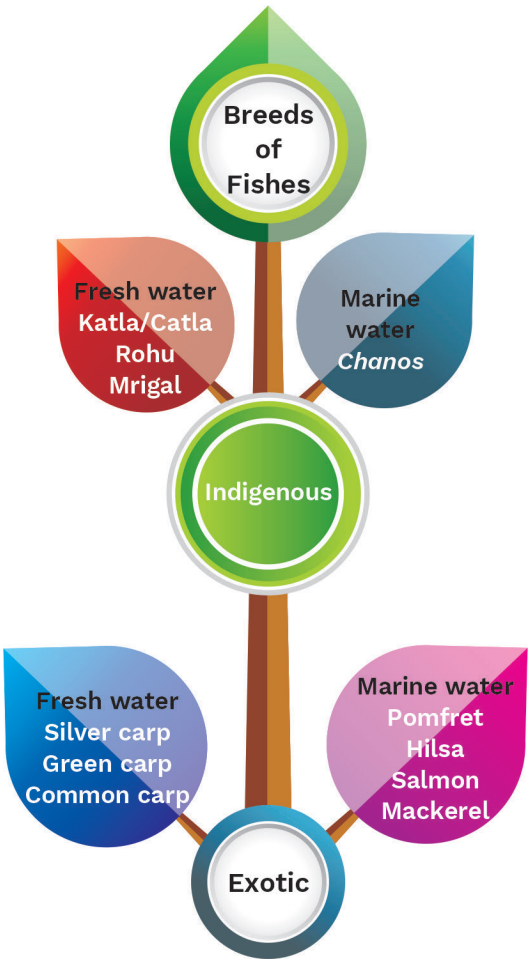
**Apiculture:** Rearing of honey bees in apiaries for the production of honey and bee wax.

*Apis mellifera*



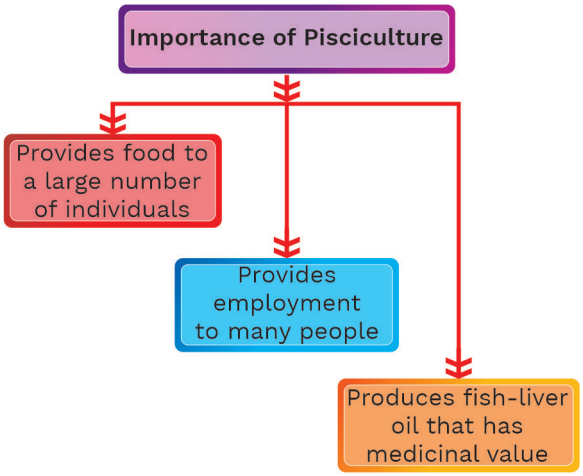

## FISH FARMING OR PISCICULTURE

- Fishery involves catching or rearing fish, shellfish or other aquatic animals.
- A large number of the population depends upon fish for their food.
- India occupies 7th position in the world in total fish production.
- Fish farming is of two types:
  - **Capture fishery –** fishes are not raised but captured directly from natural water bodies.
  - **Culture fishery –** Fishes are raised in artificial water bodies.
- Fish farming can be in marine waters or in fresh waters.




**Definition**

**Pisciculture:** The rearing and breeding of fishes for their meat is known as pisciculture.




**Gray Matter Alert!!!**

**Blue Revolution:** It was the movement launched to increase the production of fish and fish products.

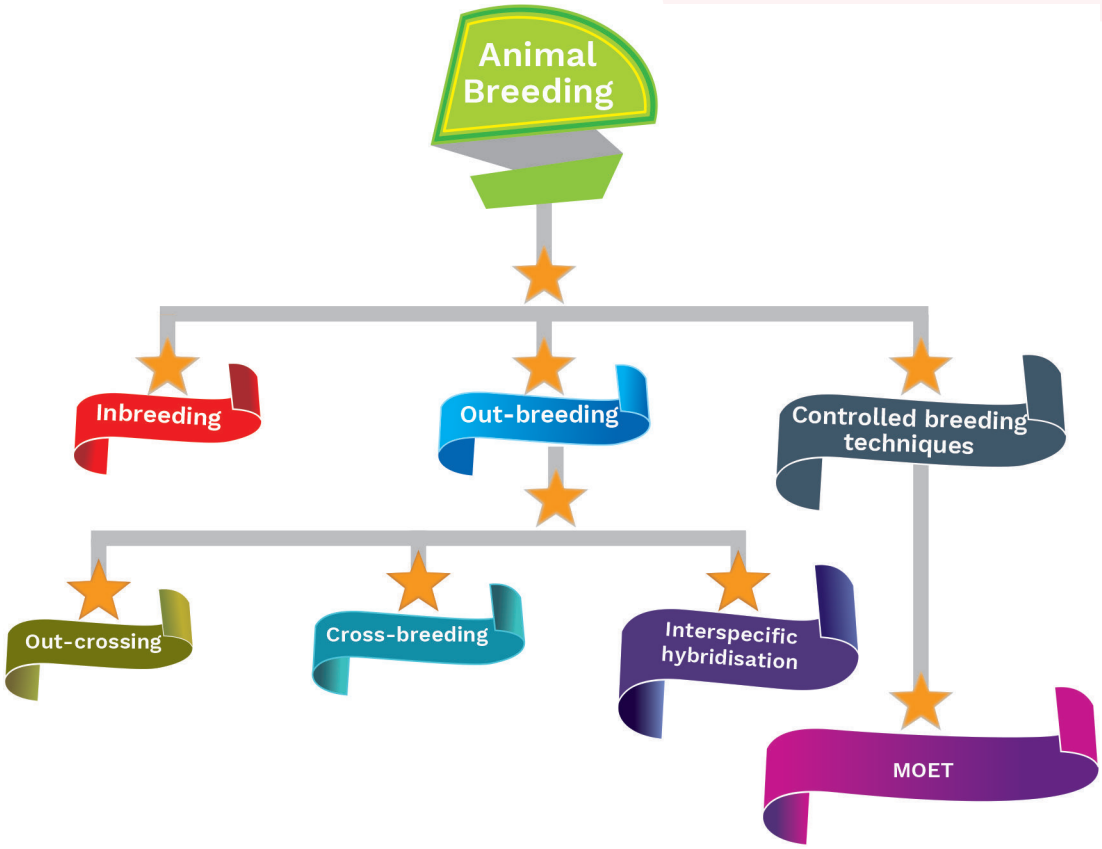
**Aquaculture:** The production of fresh water and marine plants and aquatic animals like prawns, crabs, lobsters, oysters is known as aquaculture.

**ANIMAL BREEDING**

- Animal breeding aims at:
  - Increasing the quantity of the yield.
  - Improving the quality of the production.

**Rack Your Brain**

Which areas are suitable for bee-keeping practices?



### Inbreeding

- It includes the mating of superior males and females of the same breed for 4-6 generations.
- From the progenies superior males and females are identified for further mating.

### Advantages of Inbreeding

- It increases homozygosity and thus helps in evolving purelines in animals.
- Inbreeding exposes the harmful recessive alleles, which are eliminated by selection.
- Inbreeding also helps in accumulation of superior genes and elimination of less desirable ones.

### Disadvantage of Inbreeding

- Continuous inbreeding causes inbreeding depression. It reduces vigour, fertility and even productivity.

### Solution

- To restore fertility and vigour in the animals showing inbreeding depression, the selected animals are mated with unrelated superior animals of the same breed.

### Out-breeding

- It refers to the breeding of unrelated animals either of the same breed or of different breeds or of different species.
- Outbreeding is of the following types:

### Out-crossing

- It is the process of mating animals within the same breed, having no common ancestors in both the generations of the mating animals up to 4–6 generations.
- The offspring of out-crossing is called an outcross.

**Definition**

**Inbreeding:** Inbreeding refers to the mating of more closely related individuals within the same breed for 4-6 generations.

**Previous Year's Question**

Which among the following is the real product of the honey bee?
(1) Honey
(2) Propolis
(3) Pollen
(4) Bee wax

**Definition**

**Inbreeding Depression:** It is the loss of vigour and fertility due to continuous inbreeding.

**Rack Your Brain**

How can inbreeding depression be reversed?

### Advantages of out-crossing

- Outcross helps to overcome inbreeding depression.
- Used for animals that are low in productivity.

### Cross-breeding

- It is the process in which superior males of one breed are mated with the superior females of another breed of the same species.
- The hybrid can be directly used for commercial production or they can be subjected to further inbreeding and selection, to develop new stable improved breeds.
- Example **Hisardale,** a breed of sheep developed by crossing Bikaneri ewes and Marino rams.

### Advantage of cross-breeding

- It combines the desirable qualities of the two different breeds into a hybrid.

### Interspecific hybridisation

- It is a process in which male and female animals of two different related species are crossed to combine the desirable and superior features of both the parents into one.
- Example- **Mule** is produced by a cross between a male donkey and female horse.

### Artificial Insemination

- The process in which the semen collected from superior male and is injected into the reproductive tract of the selected female.

### Advantages of artificial insemination

- Semen can be used immediately or stored at a low temperature and used later when the female is reproductively mature.
- Semen can be transported in the frozen form to a far place where the selected female is present.

**Previous Year's Question**

Interspecific hybridisation is the mating of

(1) animals within same breed without having common ancestors
(2) two different related species
(3) superior males and females of different breeds
(4) more closely related individuals within same breed for 4-6 generations

**Rack Your Brain**

What is the professional approach at genetic level that can help to increase the productivity of low milk-producing cows?

**Previous Year's Question**

A true breeding plant is

(1) one that is able to breed on its own
(2) produced due to cross-pollination among unrelated plants
(3) near homozygous and produces offspring of its own kind
(4) always homozygous recessive in its genetic constitution

- Semen from one selected male animal can inseminate many females.

**Disadvantage of artificial insemination**

- The chances of success of fertilization are low.

**MULTIPLE OVULATION EMBRYO TRANSFER TECHNOLOGY (MOET)**

- High milk-yielding breeds of females and high quality meat-yielding bulls have been bred to increase the herd size in a short span of time.

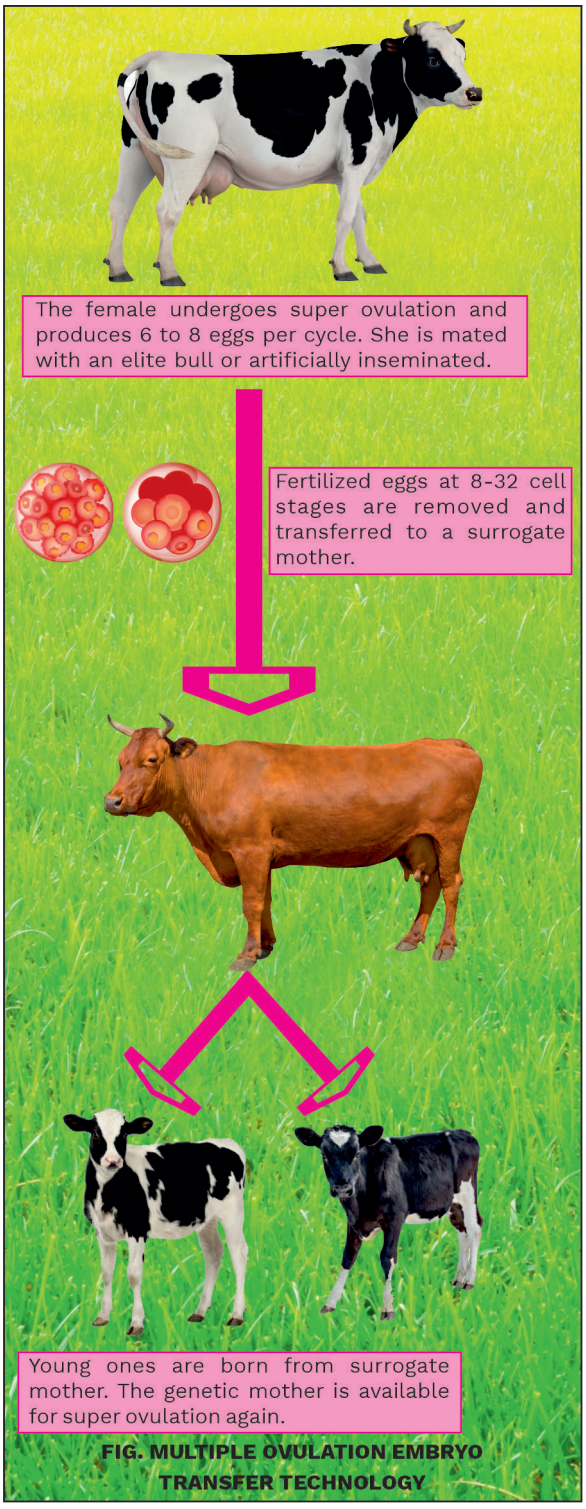



**FIG. MULTIPLE OVULATION EMBRYO TRANSFER TECHNOLOGY**

**Rack Your Brain**

What is the role of 'genetic mother' in MOET?

**Previous Year's Question**

In cloning of cattle a fertilized egg is taken out of the mother's womb and

(1) in the eight cell stage, cells are separated and cultured until small embryos are formed which are implanted into the womb of other cow

(2) in the eight cell stage the individual cells are separated under electrical field for further development in culture media

(3) from this upto eight identical twins can be produced

(4) the egg is divided into 4 pairs of cells which are implanted into the womb of other cows

**Rack Your Brain**

Name one interspecific hybrid mammal.

**PLANT BREEDING**

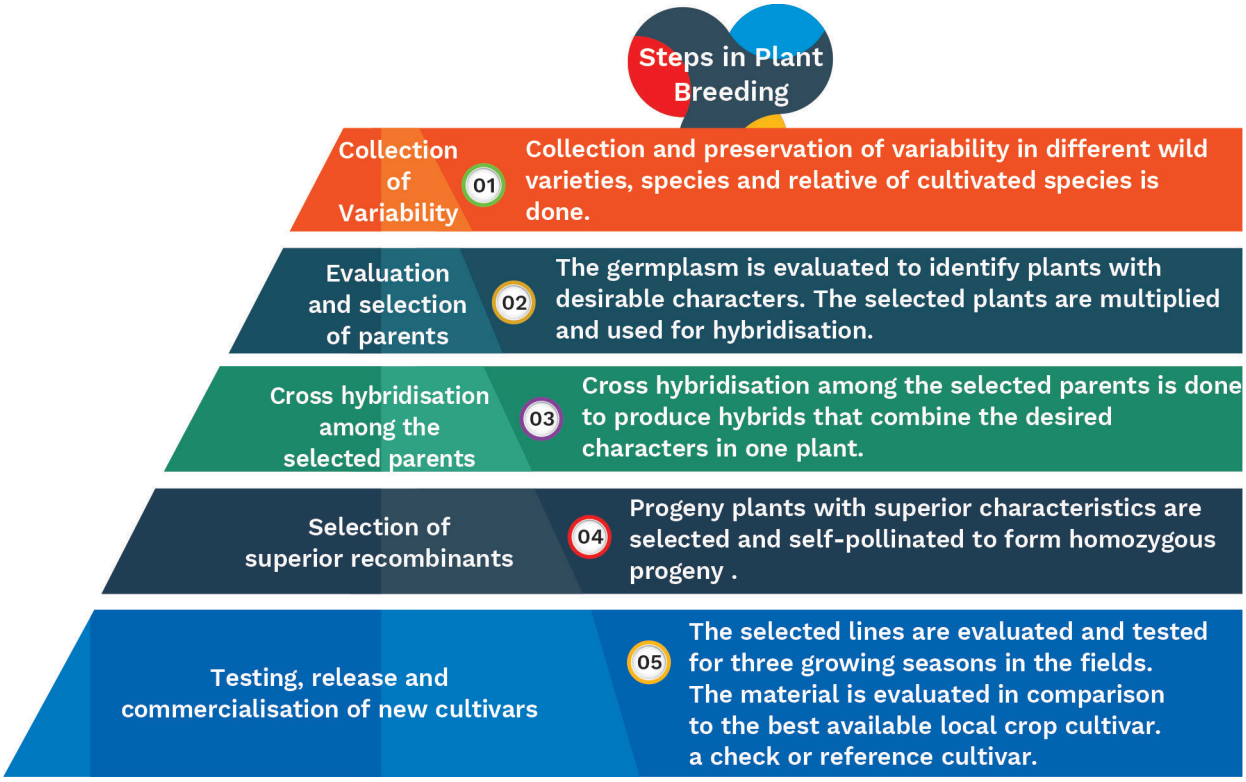
- Conventional or traditional plant breeding has been practised for many years and most of our present-day crops are the result of domestication.
- Classical plant breeding techniques involve hybridisation of purelines and selection of plants with desirable qualities.
- The list of traits that breeders have tried to incorporate into crop plants is as follows:
  - High yield
  - Quality of the product increased
  - Increased tolerance towards environmental stresses
  - Resistance to pathogens
  - Increased tolerance to an insect pest
- **The main steps in breeding a new genetic variety of a crop are:**

**Gray Matter Alert!!!**

**Monoculture:** It is the practice of growing a single crop, plant or livestock species on a farm.

**Definition**

**Germplasm:** It is the total of all the alleles of the genes present in a crop.



**GREEN REVOLUTION**

- It was launched in mid 1960's that has increased the food production to meet the food requirement.
- It used many techniques to raise high-yielding and disease resistant varieties in wheat, rice, maize.

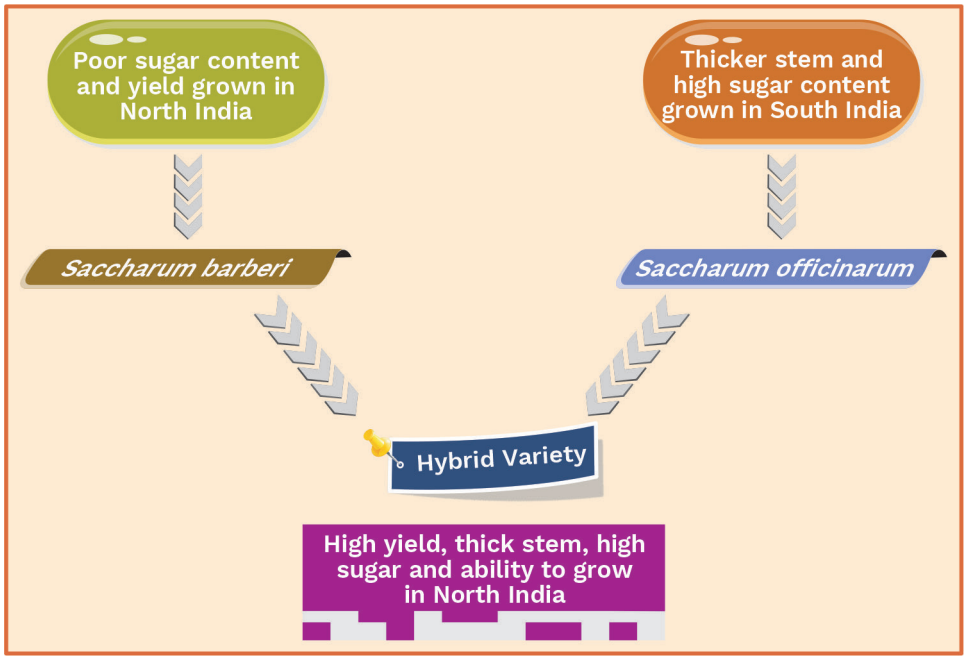
### Wheat

- **Norman E. Borlaug** developed semi-dwarf varieties of wheat at the International Centre for Wheat and Maize Improvement in Mexico.
- Varieties of wheat like ***Sonalika*** and ***Kalyan*** Sona were developed in India.
- They are high-yielding and disease resistant.

### Rice

- Semi-dwarf rice varieties were derived from IR-8 and Taichung Native-1.
- The derivatives were introduced in India in 1966.
- Better-yielding semi-dwarf varieties like ***Jaya*** and ***Ratna*** were developed in India.

### Sugarcane




**Previous Year's Question**

India's wheat yield revolution in the 1960s, was possible primarily due to

(1) hybrid seeds
(2) increased chlorophyll content
(3) mutations resulting in plant height reduction
(4) quantitative trait mutations

**Rack Your Brain**

Name one semi-dwarf variety of wheat which is high yielding and disease resistant.

### Millets

- Breeding programmes have resulted in the development of high-yielding varieties of millets resistant to water stress.

### PLANT BREEDING FOR DISEASE RESISTANCE

- Plant breeding for disease resistance has two advantages:
  - Enhanced food production.
  - Reduced dependence on the use of chemicals pesticides, insecticides and fungicides.
- Resistance is the ability of the plant to prevent the pathogen from causing disease.

**Table. Pathogens and their Diseases**

| Causative Agent | Diseases |
|---|---|
| Virus | Tobacco mosaic, Turnip mosaic |
| Bacteria | Black rot of crucifers, citrus canker, blight of rice |
| Fungi | Rust of wheat, red rot of sugar cane, late blight of potato |

- The steps involved in the conventional method of breeding for resistance are:
  - Screening the germplasm for resistant sources.
  - Hybridisation of selected parents.
  - Selection and evaluation of the hybrids.
  - Testing and release of the new varieties.

**Definition**

**Resistance:** It is the ability of the plant to prevent the pathogen from causing disease.

**Previous Year's Question**

Crop plants grown in monoculture are
(1) highly prone to pests
(2) low in yields
(3) free from intraspecific competition
(4) characterised by poor root system

**Table. Crops Resistance to Diseases Caused by Pathogens**

| Crop | Variety | Resistance to disease(s) |
|---|---|---|
| Cauliflower | *Pusa Shubhra*<br>*Pusa Snowball K-1* | Black rot, curl blight black rot |
| Wheat | *Himgiri* | Leaf and stripe rust and hill bunt |
| *Brassica* | *Pusa Swarnim* | White rust |
| Cowpea | *Pusa Komal* | Bacterial blight |
| Chilli | *Pusa Sadabahar* | Chilly mosaic, tobacco mosaic and leaf curl |

- The gene for resistance to yellow mosaic virus was found in a wild species of bhindi having a low yield.It has been transferred from the wild species to form a new variety of ***Abelmoschus esculentus,*** called ***Parbhani kranti.***
- Since there is limited availability of disease resistant genes in the crop plants and their wild relatives, thus mutation breeding is carried out for disease resistance.
- By mutation,the DNA is being modified and thus disease resistant gene(s) is/are created.
- **Mutation breeding** involves the following steps:
  - Inducing mutation(s) through chemicals or mutagens.
  - Screening the plant materials for disease resistance or genes with desirable benefits.
  - Multiplication of the selected plants for direct use or for breeding.
- Example-**Mung bean** has been developed by mutation breeding and has developed **resistance to yellow mosaic virus and powdery mildew.**

**Definition**

**Mutagens:** Mutation causing agents are called mutagens.

**Previous Year's Question**

Which of the following is generally used for induced mutagenesis in crop plants?
(1) X-rays
(2) UV (260 nm)
(3) Gamma rays (from cobalt 60)
(4) Alpha particles

### Disadvantages of Mutations

- Some mutations can be lethal and the plants may be killed.
- It may not always give the desired results.
- Mutations will only be inherited if they occur in the germ cells.

FIG. MORPHOLOGICAL ADAPTATION

### PLANT BREEDING FOR RESISTANCE TO INSECT PESTS

- Insect pest resistance in crops can be in the form of
  - **morphological**
  - **physiological**
  - **biochemical**

**Table. Crops Resistance to Diseases Caused by Insect Pest**

| Crop | Characteristics | Features | Resistance to pest(s) |
|---|---|---|---|
| Wheat | Morphological | Hairy leaves<br>Solid stem | Cereal leaf beetle<br>Stem sawfly |
| Cotton | Morphological and physiological | Hairy leaves<br>Smooth leaves and nectarless condition | Jassids<br>Bollworm |
| Maize | Biochemical | High aspartic acid and low nitrogen and sugar contents | Stem borer |

- Breeding for pest-resistance follow the same steps as breeding for disease resistance.
- The following are good sources of resistance genes:
  - Cultivated varieties
  - Germplasm collections of crop or wild relatives

**Table. Crops Resistant to Diseases Caused by Pests**

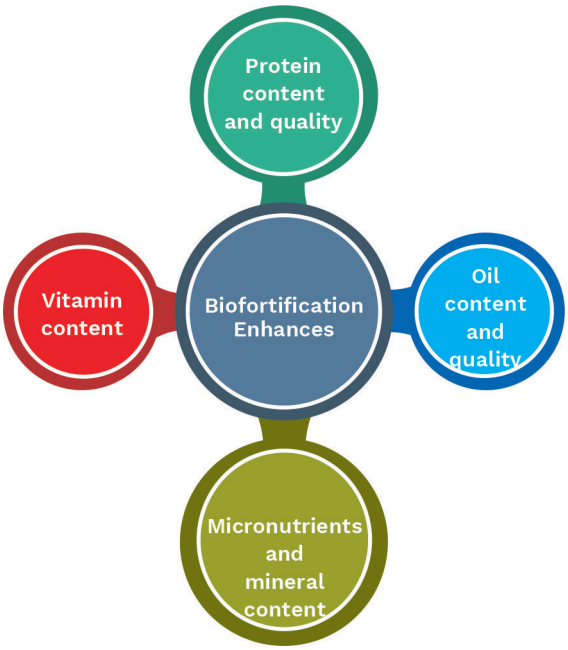
| Crop | Variety | Resistance to pest(s) |
|---|---|---|
| Okra (bhindi) | *Pusa Sawani, Pusa A–4* | Shoot and fruit borer |
| *Brassica* (Rapeseed) | *Pusa Gaurav* | Aphids |
| Flat bean | *Pusa Sem–2, Pusa Sem–3* | Jassids, aphids and fruit borer |

## PLANT BREEDING FOR IMPROVED FOOD QUALITY

- A large number of people in the world do not receive their daily nutritional requirement of vitamin A, iron, iodine and zinc. This is known as hidden hunger .
- Hidden hunger can reduce the life span, cause diseases and reduce the mental abilities of the people.
- One of the methods for developing crops with higher levels of these nutrients is biofortification.
- Biofortification is the breeding of plants with higher levels of proteins, vitamins, minerals and healthy fats.
- **Examples of crop varieties, developed in India by biofortification are:**
  - Lysine and tryptophan-rich varieties of maize.
  - High protein variety of wheat. E.g., Atlas 66
  - Iron-fortified variety of rice.
  - Vitamin C rich – Bitter gourd, tomato, mustard, bathua.
  - Iron and Calcium rich – Spinach and bathua.
  - Protein rich – French beans, Lablab beans, Broad bean and Garden peas.

**Definition**

**Biofortification:** It is the breeding of plants with higher levels of proteins, vitamins, minerals and healthy fats.



- Vitamin A rich – Carrots, spinach and pumpkin.

**SINGLE CELL PROTEIN (SCP)**

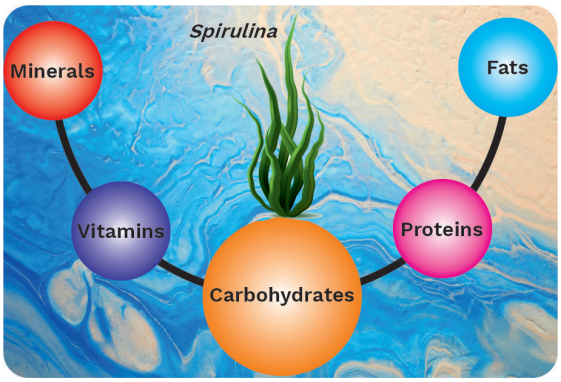
- Protein is an important nutrient of our daily diet. Each individual needs an adequate amount of protein that they can get from pulses and meat.
- A large amount of grains are needed to feed the animals and thus to obtain proteins.This again puts a lot of pressure on the generation of more cereals.
- Single cell protein is one of the alternative source of proteins for nutrition of humans and animals.
- Microbes are grown on a large scale and used as nutrient-rich food. Example-***Spirulina***

**Advantages of Single Cell Protein:**

- Rich in proteins, minerals, vitamins and carbohydrates and fats.
  - Can be easily grown on waste water from potato processing plants, animal manure, molasses.
  - The use of waste material reduces pollution.
  - They reduce the pressure of cultivating a large amount pulses, for e.g., 250 g of *Methylophilus methylotrophus* bacterium has been used to produce 25 tonnes of protein while 250 kg of cow produces 200g of proteins and a lot of pulses are needed to fulfil the nutritional requirement of the cattle.

**TISSUE CULTURE**

- Some parts of a plant like the leaf, stem, root, anther, ovary have the ability to generate a whole new plant and this is known as **totipotency.**
- The first evidence of cellular totipotency was given by F.C Steward.
- This ability of plants is used in tissue culture technique.
- It is the technique of regeneration of whole plant from any part of a plant(explants) by growing it in a suitable nutrient medium under aseptic conditions *in vitro*.




**Previous Year's Question**

Breeding of crops with high levels of minerals, vitamins and proteins is called
(1) somatic hybridisation
(2) biofortification
(3) biomagnification
(4) micropropagation

**Definition**

**Plant Tissue Culture:** It refers to the regeneration of whole plant from any cell or tissue or organ of a plant in a suitable nutrient medium *in vitro*.

- It is also known as micropropagation as large number of plants can be grown in a short period of time.
- The plants produced are genetically identical and are known as somaclones.
- **Materials required-**Explant, nutrient petri dish, hormones (auxins, cytokinins), agar.
- **Conditions required-**Aseptic, proper aeration.
- **Procedure-**Explant is taken and sterilised and then placed on a petri dish with the nutrient medium.This is carried out in a sterile laminar airflow.
- The cells of the explants and multiply and form a multicellular structure known as callus.
- The rooting and shooting hormone auxins and cytokinins are added to the petri dish containing the callus.
- Within a few weeks roots and shoot develop and then the new plantlets are shifted to the fields.

### Advantages of Tissue Culture

- Large number of plants can be grown in a short span of time.
- Seedless plants can be grown.
- Less space is needed to grow the plants.
- Characteristics of the parent plant is passed to the offsprings.

**Note:** Pollen grains, anthers, ovaries and ovules are haploid explants. Colchicine is added to the culture medium to generate diploid plantlets from them.

### MERISTEM CULTURE

- Meristematic tissue is taken from the tip of the plant.E.g., Shoot or root tip.
- The tip of the plant is used as it is free of virus.
- The tissue is grown in a nutrient medium along with auxins and cytokinins.

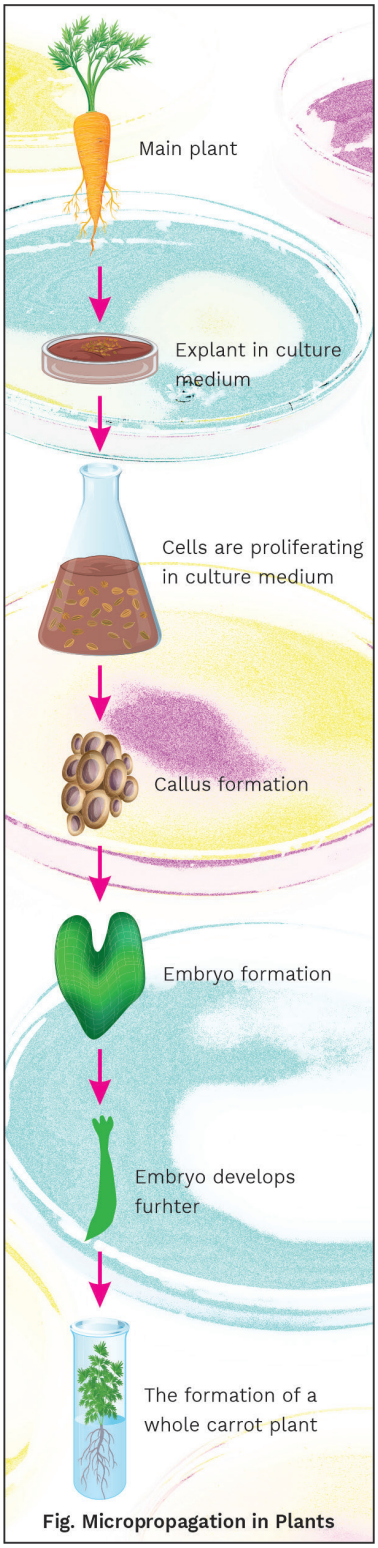



**Fig. Micropropagation in Plants**

- New plantlets develop from the meristematic tissues.

### Advantages of Meristem Culture

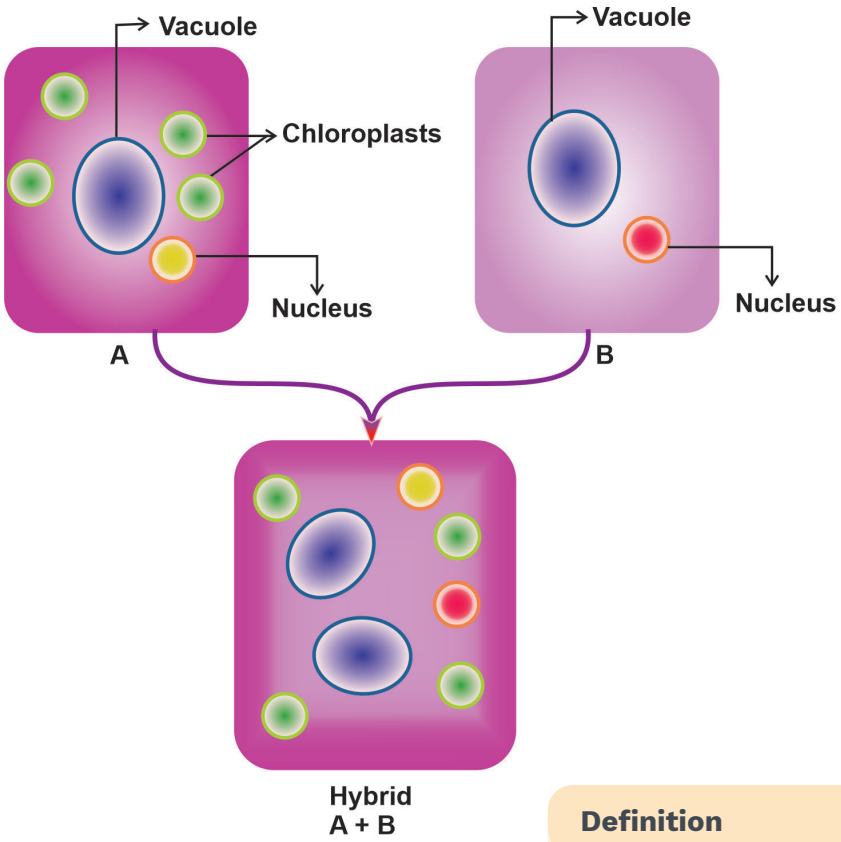
- Rapid multiplication of the plants.
- Production of virus-free plants.
- Used for conservation of germplasm.

### SOMATIC HYBRIDISATION

- Somatic hybridisation is the process of fusing protoplasts of somatic cells derived from two different plants in a suitable nutrient/culture medium, under aseptic/sterile conditions.

**Definition**

**Somatic Hybridisation:** The process of fusion of protoplasts of somatic cells derived from two different plants in a suitable nutrient culture medium.




- The process includes the following steps:
- Protoplast is taken from the cells of the leaves, roots, callus, pollen grains. The plant parts are first sterilised in ethyl alcohol.

**Definition**

**Somaclones:** Genetically identical plants developed from any part of a plant by tissue culture.

- Isolation of protoplasts by digesting the cell wall by use of enzymes. Microenzyme, Cellulase are used etc.
- Fusion of the protoplasts of the selected varieties.
- Fusion of the protoplast can be induced by Sodium nitrate treatment, Calcium treatment, Polyethylene glycol (PEG) and by electrical fusion.
- This results in the hybrid of the desired characteristics of both the plant protoplasts.
- The fused protoplast is grown in a suitable culture medium, and differentiate to form somatic hybrids. This process is known as somatic hybridisation.
- Example- Pomato produced by fusion of protoplasts of tomato and potato.

**Advantages of Somatic Hybridisation**

- Somatic hybrids can be raised where sexual hybridisation is not possible.
- Desired qualities of two plants can be combined by protoplast fusion.

**Rack Your Brain**

Are somatic hybrids and somaclones the same?

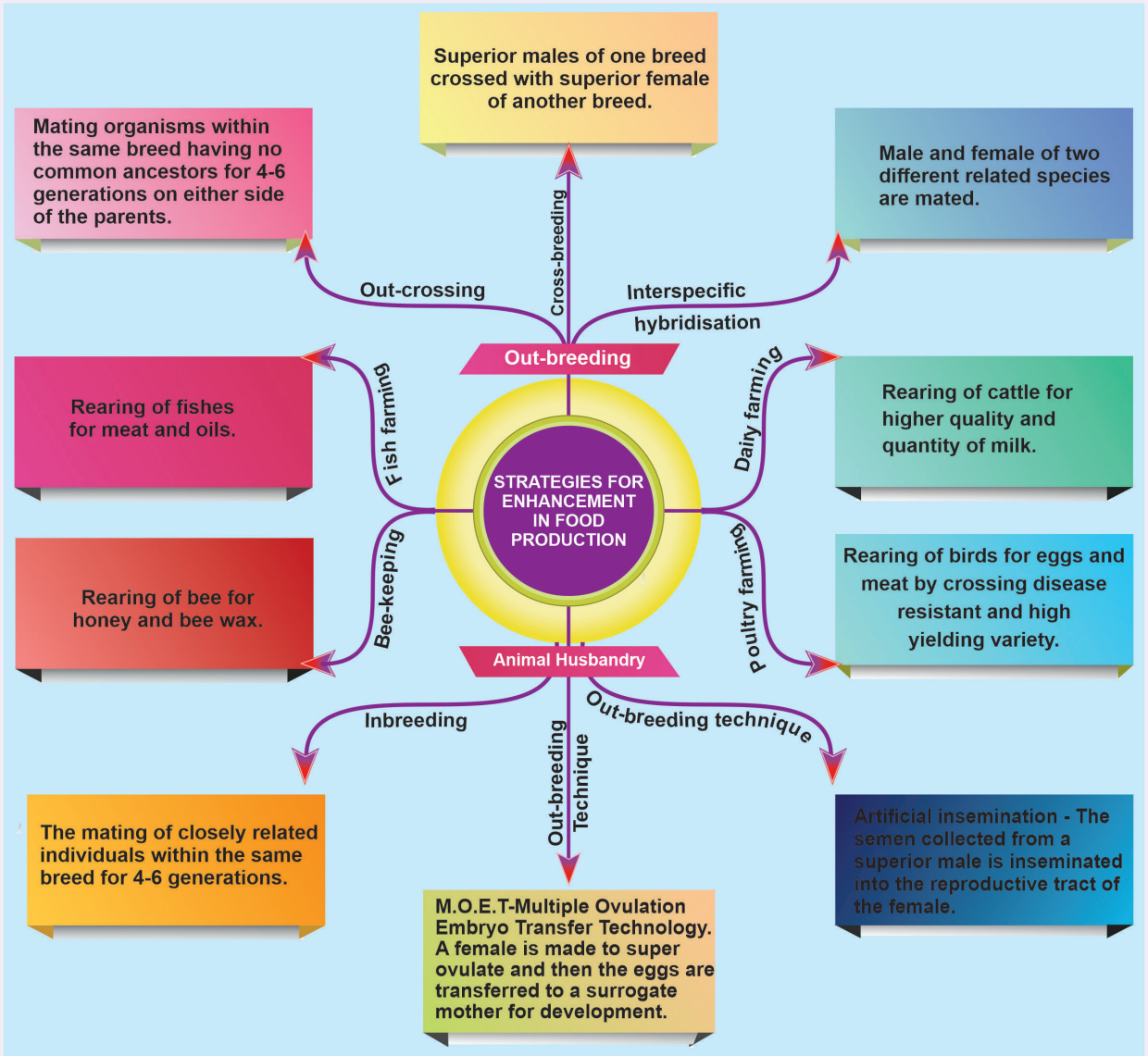
**Previous Year's Question**

Somaclones are obtained by
(1) plant breeding
(2) irradiation
(3) genetic engineering
(4) tissue culture

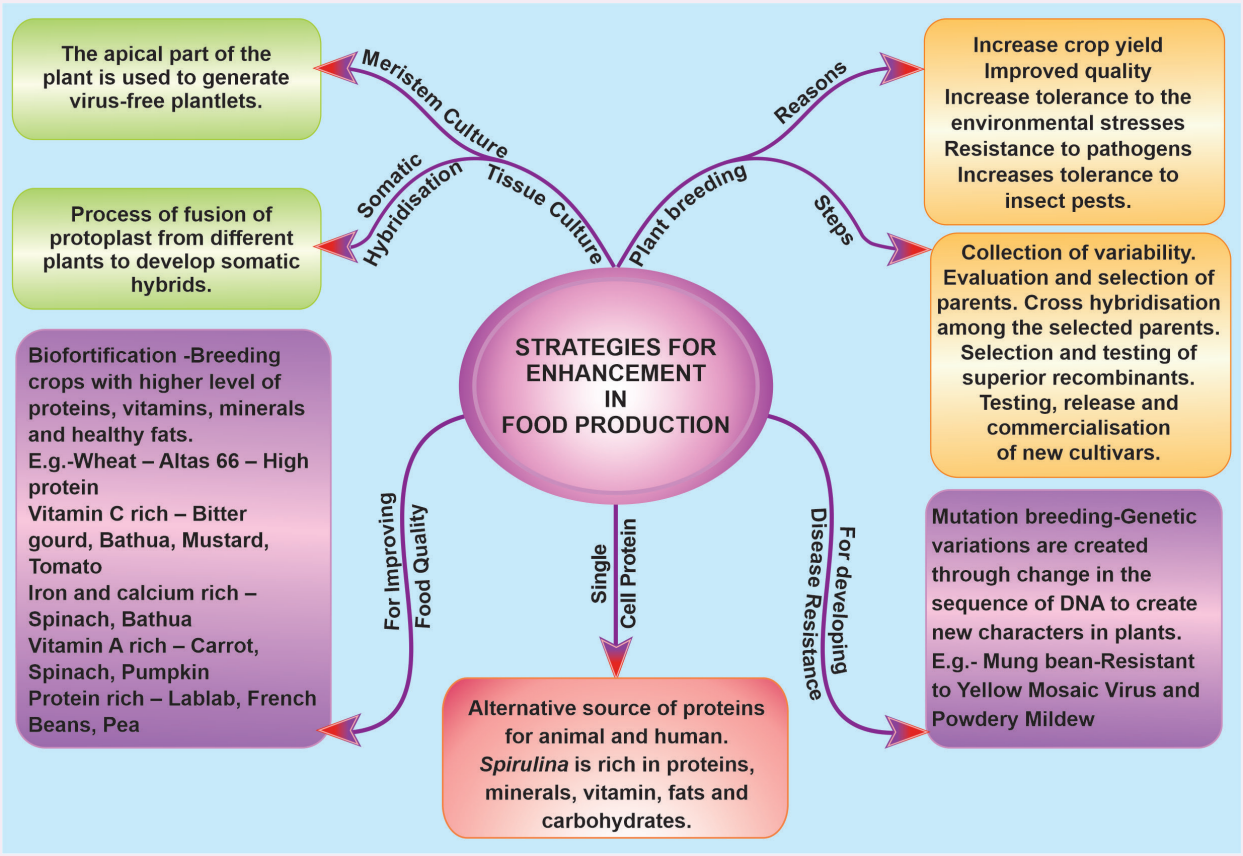
**Rack Your Brain**

Mention two limitations of traditional breeding techniques.

## Summary


STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION
Out-breeding
Animal Husbandry
Cross-breeding
Out-crossing
Interspecific hybridisation
Inbreeding
Out-breeding Technique
Out-breeding technique
Fish farming
Dairy farming
Bee-keeping
Poultry farming
Superior males of one breed crossed with superior female of another breed.
Mating organisms within the same breed having no common ancestors for 4-6 generations on either side of the parents.
Male and female of two different related species are mated.
Rearing of fishes for meat and oils.
Rearing of cattle for higher quality and quantity of milk.
Rearing of bee for honey and bee wax.
Rearing of birds for eggs and meat by crossing disease resistant and high yielding variety.
The mating of closely related individuals within the same breed for 4-6 generations.
M.O.E.T-Multiple Ovulation Embryo Transfer Technology. A female is made to super ovulate and then the eggs are transferred to a surrogate mother for development.
Artificial insemination - The semen collected from a superior male is inseminated into the reproductive tract of the female.

## Summary


STRATEGIES FOR ENHANCEMENT IN FOOD PRODUCTION
Tissue Culture
Meristem Culture
The apical part of the plant is used to generate virus-free plantlets.
Somatic Hybridisation
Process of fusion of protoplast from different plants to develop somatic hybrids.
Plant breeding
Reasons
Increase crop yield
Improved quality
Increase tolerance to the environmental stresses
Resistance to pathogens
Increases tolerance to insect pests.
Steps
Collection of variability.
Evaluation and selection of parents. Cross hybridisation among the selected parents.
Selection and testing of superior recombinants.
Testing, release and commercialisation of new cultivars.
For Improving Food Quality
Biofortification -Breeding crops with higher level of proteins, vitamins, minerals and healthy fats.
E.g.-Wheat – Altas 66 – High protein
Vitamin C rich – Bitter gourd, Bathua, Mustard, Tomato
Iron and calcium rich – Spinach, Bathua
Vitamin A rich – Carrot, Spinach, Pumpkin
Protein rich – Lablab, French Beans, Pea
Single Cell Protein
Alternative source of proteins for animal and human.
Spirulina is rich in proteins, minerals, vitamin, fats and carbohydrates.
For developing Disease Resistance
Mutation breeding-Genetic variations are created through change in the sequence of DNA to create new characters in plants.
E.g.- Mung bean-Resistant to Yellow Mosaic Virus and Powdery Mildew

**Solved Exercise**

**Q1** **The name of Norman Borlaug is associated with**
**(1) white revolution**
**(2) green revolution**
**(3) yellow revolution**
**(4) blue revolution**

**A1** **(2)**
Norman Borlang is credited with green revolution that increased food grain production in the world.

**Q2** **A protoplast is a cell**
**(1) undergoing division**
**(2) without cell wall**
**(3) without plasma membrane**
**(4) without nucleus**

**A2** **(2)**
Protoplast is the cytoplasm and the nucleus removed from the cell.

**Q3** **Out-breeding is an important strategy of animal husbandry because it**
**(1) is useful in overcoming inbreeding depression**
**(2) exposes harmful recessive genes that are eliminated by selection**
**(3) helps in accumulation of superior genes**
**(4) is useful in producing purelines of animals**

**A3** **(1)**
Continuous inbreeding causes inbreeding depression that can be eliminated by outbreeding i.e., out-crossing.

**Q4** **A technique of micropropagation is**
**(1) protoplast fusion**
**(2) embryo rescue**
**(3) somatic hybridisation**
**(4) somatic embryogenesis**

**A4** **(4)**
Somatic embryogenesis is a technique of micropropagation in which new plantlets develop from somatic cells.

**Q5** **Which of the following enhances or induces fusion of protoplasts?**
**(1) IAA and kinetin**
**(2) IAA and gibberellins**
**(3) Sodium chloride and potassium chloride**
**(4) Polyethylene glycol and sodium nitrate**

**A5** **(4)**
Polyethylene glycol and Sodium nitrate induce the fusion of two different protoplasts.

**Q6** **Tissue culture medium, the embryoids formed from pollen grains are due to**
**(1) cellular totipotency**
**(2) organogenesis**
**(3) double fertilisation**
**(4) test tube culture**

**A6** **(1)**
Totipotency is the ability of the cells to multiply and form new plants.

**Q7** **Which statement is correct?**
**(1) *A. indica* is largest wild honey bee.**
**(2) Wax is waste product of honey bee.**
**(3) Workers are the smallest of the three castes.**
**(4) Drone of honey bee is diploid**

**A7** **(3)**
Workers are the smallest of the three castes. *A. florea* is the smallest wild honey bee. Wax is a product of honey bee. Drone honey bee is haploid.

**Q8** **The new varieties of plants are produced by**
**(1) introduction and mutation**
**(2) selection and introduction**
**(3) selection and hybridization**
**(4) mutation and selection**

**A8** **(3)**
Selection of plants with desirable traits and then hybridizing them to produce new improved varieties.

**Q9** **High milk yielding varieties of cows are obtained by**
**(1) use of surrogate mothers**
**(2) super ovulation**
**(3) artificial insemination**
**(4) all of these**

**A9** **(4)**
High milk yielding varieties of cows can be obtained by MOET by artificial insemination, super ovulation, and use of surrogate mother.

**Q10** **The term aquaculture means**
**(1) inland fisheries**
**(2) aspergillosis**
**(3) marine fisheries**
**(4) both (1) and (3)**

**A10** **(4)**
Aquaculture is the rearing of inland and marine fisheries.