CHAPTER 7

Applied Biology

Fertilizers

- Fertilizers can be of two types
  (a) Chemical fertilizers (b) Biofertilizers

Chemical Fertilizers

- Salt or an organic compound containing the necessary plant nutrients is called fertilizers. Ammonium sulphate is an inorganic fertilizer. Urea is an organic fertilizer.

Types of Chemical Fertilizer

Nitrogenous Fertilizers (Nitrogen containing fertilizer)

- Ammonium nitrate NH_4NO_3
- Ammonium sulphate $(NH_4)_2SO_4$
- Sodium nitrate $NaNO_3$
- Urea NH_2CONH_2 (organic fertilizer)

Phosphatic Fertilizers (Phosphorus containing fertilizers)

- Ammonium phosphate $(NH_4)_3PO_4$
- Ammonium hydrogen phosphate $(NH_4)H_2PO_4$
- Super phosphate $Ca_2(H_2PO_4)_2$

Potassium Fertilizers (Potassium containing fertilizers)

- Potassium chloride KCl
- Potassium nitrate KNO_3
- Potassium sulphate K_2SO_4
- Calcium ammonium nitrate (CAN) also called as Kisan Khad.
- NP and K also called as complete fertilizer.

Biofertilizers

- **Biofertilizers** are those organisms which can bring about nutrient availability to crop plants.
- Natural process fixes about 190×10^{12} g/year (8%) of nitrogen through lightning, 2% by photochemical reactions and 90% by biological nitrogen fixation.

Some Profertilizers are

Free Living Nitrogen Fixing Bacteria

Non-symbiotic (free-living) nitrogen fixing bacteria are found abundandy in rhizosphere (i.e., the region where the soil and roots make contact). They may be aerobic or anaerobic.

(a) **Aerobic nitrogen fixing bacteria** Aerbic nitrogen fixing bacteria such as *Azotobacter* are thought to maintain reduced oxygen conditions (micro aerobic conditions) throuth their high leves of respiration. Others such as *Gloeothece* evolve O_2 photosynthetically during the day and fix nitrogen during the night.

(b) **Anaerobic nitrogen fixing bacteria** In anaerobic nitrogen fixing bacteria, oxygen does not pose a proble, because it is absent in their habitat. They can be either phocosynthetic (e.g., *Rhodospirillum*) or non-photosynthetic (eg, Clostridium)

Symbiotic Nitrogen Fixing Bacteria

Many plants form a symbiotic relationship with nitrogen fixing bacteria that contain an enzyme complex nitrogenase. Nitrogenase enzyme can reduce nitrogen into ammonia. The best known example of symbiotic nitrogen fixation is that of the *Rhizobium* group of bacteria which form nodules on the roots of leguminous plants. Nodules contain an oxygen binding haem protein called leghaemoglobin. Leghaemoglobin is pergent in the cytoplasm of infected nodule cells at high concentration and gives the nodules a pink colour. Non-leguminous trees and shrubs such as *Alder, Ceanothus* and *Purshia* have the **nitrogen fixing Actinomycetes** *Frankia* as a symbiont.

Free Living Nitrogen Fixing Cyanobacteria

Anabaena, nostoc, aulosira, cylindrospermum, trichodesmium, etc., are some free living nitrogen fixing blue-green algae or cyanobacteria. They add 20-30 kg of nitrogen per hectare of soil and water. *Aulosira* is the most active nitrogen fixer in rice field whereas *Cylindrospermum* is active in sugarcane and maize fields.

Symbiotic Nitrogen Fixing Cyanobacteria

Anabaena and *Nostoc* sp of cyanobacteria are common symbionts in lichens, *Anthoceros, Azolla* and *Cycads* roots. The water fern *Azolla* has *Anabaena azollae* as the symbiont which fixes nitrogen within fronds. They grow thickly in rice paddy water and often inoculated to rice fields for nitrogen fixation.

Mycorrhiza

Mycorrhizae (singular mycorrhiza) are the mutualistic association of a fungus and the roots of higher plants. Mycorrhizae and found in most groups of vascular plants. There are two types of mycorrhizae.

(a) **Ectomycorrhiza** The ectotrophic mycorrhizal fungi is present on the root surface. The cortical cells are surrounded by a network of hyphae called **Hartig net**. It is found in roots of oak, *Pinus*, peach, eucalyptus, etc.

(b) **Endomycorrhiza** The mycorrhizal fungus enters the roots and spread in the root cortex. It may be intercellular or intracellular. The type of endomycorrhiza which produce vesicles and arbuscules inside the cortical cells of roots are called **VAM** (Vesicular Arbuscular Mycorrhiza) *e.g.*, Orchids, common crop plant and grasses.

Manures

- Manure is an organic fertilizers.
- It is decomposed product of organic wastes.
- Famers in our country are traditionally using cow-dung as manure.

Green Manuring

Green manure is a type of cover crop grown primarily to add nutrients and organic matter to soil. The technique of utilizing green manure is called green manuring. *e.g.*, leguminous plants such as *Crotalaria juncea, Glycine max, Indigofera linifolia*, etc., are used as green manures.

- *Anabaena azollae* cynobacteria used as biofertilizer in rice field.
- Sunnhemp plants is used for green manuring in India.

Advantages

- Improves soil fertility.
- Improves soil structure.
- Improves soil aeration.
- Controls insects, pests, mites nematodes, etc.
- Controls weeds.

Weed

- Wild plants which grow alongwith a cultivated crop are called weeds common weeds found in wheat and rice field are *Phalaris minar* (Mandusi), *Amaranthus* (Chaulai), *Chenopdium* (Bathua).
- Exotic weeds are *Parthenium hysterophorus, Eichhornia*, etc.
- Most troublesome terrestrial weed is congress grass (*Parthenium hysterophorus*).

Weedicides

- These are chemical substances that are used to kill weeds. Some weedicides are butachlor, 2,4-D (2, 4-dichlorophenoxy acetic acid), MCPA (2-methyl 4-chloro, 1-phenoxy acetic acid).

Pesticides

- Pesticides are used to destroy pests (pathogens, weeds, insects, rodents, etc.) by spraying the crop.
- **Bordeaux mixture** (a fungicide) composed of $CuSO_4$, $Ca(OH)_2$ and Ho_2 was discovered by Millardet.
- Some common pesticides are warfarin sulphur, malathion, DDT (Dichloro diphenyl trichloro ethane), BHC (Benzene hexa chloride), etc.
- Endosulfan is an organochlorine pesticide and acaricide used on plants and insects.
- DDT and 2,4-D were mainly used during the second world war.
- Methly isocyanate gas, which is responsible for Bhopal gas tragedy (3rd Dec, 1984), is used for synthesising carbryl (selvin).
- Rotenone is obtained from roots of *Derris eliptica and Lonechocarpus*.

Hybridization

- Cross breeding of different varieties of crop to get a new crop with desired characteristics. Such crops/varieties are called **High Yielding Varieties** (HYV) or **hybrid**.
- High yielding varieties of wheat are **Lerma, Sharbati Sonara, Kalyan Sona, Roja 64, Pusa Lerma, Hera-Moti, Sonara-64, Sonalika** and **Arjun**.
- High yielding varieties of paddy (rice) are **Jaya, Padma, Pusa 205, IR-8, T-141**.
- High yielding varieties of maize are **Ganga-101, Ranjit, Daccan** hybrid.

Green Revolution (1940-70)

- Green revolution refers to a series of research, development and technology transfer intiatives that increased agricultural production around the world. Great increase in the production of food grain crops due to use of hybrid varieties, fertilizers and modern agricultural techniques took place.
- Father of green revolution in India is **MS Swaminathan** and in world is **NE Borlaug.**

Pisciculture

- The breeding, rearing and transplantation of fish by artificial means is called pisciculture. It involves raising fish commercially in tanks or enclosures usually for food.
- **Freshwater fishes** Rohu, catla, carp, tirica, malli, singhara and calbasu.
- **Marine fishses** Bombay duck, conger eel, promphert, salmon, sardine.
- Fish are rich source of protein and vitamin-A and D.

High Yielding Breeds of Animals

- **Cows** Karan Swiss, Sunandini, Jersey-Sindihi, Brown Swis-Sahiwal, Friesion-Sahiwal, etc.
- **Buffalo** Murrah, Surti, Jaffarabadi, Nili, Nagpuri, etc.

- **Goat** Kashmiri, Gaddi, Bengal, etc.
- **Sheep** Gaddi, Lohi, Bikaneri, Gurez, Nillore, etc.
- **Pig** Large white Yorkshire, Middle white Yorkshire, etc.
- Pashmina (fine wool) is obtained from mountain (Kashmiri) Goat.
- **Indigenous Hens** Aseel, Basara, Chittagong, Ghagus, Brahma and Cochin.
- **Exotic High Egg Yielding Breeds of Hens** White leghorn, Rhode Island Red, Black Minonca, Plymoth Rock and Light sussex.
- High yielding breeds of hens developed in India by cross breeding of indigenous varieties with the foreign breeds are ILS-82, HH-260 and B-77.

Artificial Insemination

- It is the process in which the stored semen of a desired male animal is introduced into the genital tract of a selected female animal by using suitable instruments, for carrying out reproduction, to get a better breed of the animal or to solve the problem of infertility.

Animal Husbandry

Animal husbandry is agricultural practice of breeding and raising livestock.

Operation Flood (White Revolution)

- Great increase in the production of milk due to use of high mild yielding breads of cow and buffaloes.
- It resulted in making India the largest producer of milk and milk products and hence called white revolution.
- Operation flood was rural programme started by India's National Dairy Development Board (NDDB) in 1970.

Silver Revolution

- Great increase in the production of eggs due to use of exotic breeds.

Genetic Engineering

- **PCR (Polymerase Chain Reaction)** Discovered by Kary Mullis (1985). It is a technique of amplification of DNA segment with the help of *taq* polymerase (isolated from *Thermus aquaticus*).
- **Bioasphalt** is an asphalt alternative made from non-petroleum based renewable resources like sugar, natural tree and gum resins, etc.
- **Gene Therapy** is the insertion of genes into an individual's cell or tissues to treat disease(s).
- **Terminator Technology** is a technology that altered seeds which fail to germinate after the first generation.
- **Golden Rice** is a transgenic rice biosynthesising beta-carotene, vitamin-A, precursor in the edible parts of rice.
- **Sweet Bug** a bacterium that turns coconut water into delicious confectionary. The bacteria used is *Acetobacter xylinum*.
- **Prof. Anand Mohan Chakraborty**, has developed a new strain of oil eating bacteria called 'Superbug' by using species of *Pseudomonas*.
- **Organic foods** Foods produced by using methods free of inputs such as synthetic pesticides, chemical fertilizers, chemical additives, irradiation, etc.
- **Biodegradable Plastic Films (PVC)** made by blending the polymers with (i) an additive to provide an oxidative or (ii) starch.

DNA Fingerprinting

- Technique employed by forensic scientists to assist in the identification of individuals by their respective DNA profiles.
- Invented by Dr. Alec Jeffreys.

Process

- Collection of sample (most preferably buccal swab).
- RFLP analysis
- (Restriction fragments Length Polymorphism).
- Southern blotting.
- But the above method is quite laborious and requires large amount of undegraded sample so the method was replaced by what is used today based on STR (Short Tandem Repeats) and PCR.

Cloning

- Cloning in biology is the process of producing similar populations of genetically identical individuals that occurs in nature when organisms such as bacteria, insects or plants reproduce asexually.
- There are two types of cloning:
  (a) **Reproductive Cloning** for the production of offspring. In it a new individual is created from a single cell by replacing the nucleus in an egg cell with the nucleus (containing the genetic material) from another cell of the body. The cloned egg cell grows and develops into an embryo. The embryo is implanted inside a surrogate mother's womb to mature and produce a viable foetuses.
  (b) **Therapeutic Cloning** It is used for development of embryonic stem cells.
- The inner cell mass of the blastocyst is then removed and used for the creation of an embryonic stem cell line that has the genetic make up of the donated nucleus.
- **Dolly** a sheep, the first mammal clone synthesized by **Dr. Ian Wilmut**, UK.

- **Noori** The world's first cloned Pashmina goat has been named as Noori, an arabic word referring to light. Funded by World Bank, the clone project was jointly worked by SKAUST and Karnal based National Dairy Research Institute (NDRI). The world's first buffalo calf through the Handguided Cloning Technique was born on 6 February, 2009 at NDRI, Karnal.
- Garima-II, another cloned buffalo, calf through the new and advanced 'Hand-guided Cloning technique' was born at NDRI, Karnal.

Stem Cell Therapies

- The most promising used of stem cells is due to their ability to be modified into diferent functional adult cell types and serve as a potential source of replacement cells to treat numerous diseases.
- Stem cell research involves the use of several different types of cells besides embryonic stem cell, such as adult stem cells from humans or animals or stem cells from foetuses umbilical cord or amniotic fluid.

Bt Crops

- *Bt* crops are produced by inserting the genes which code for the toxin directly into the genetic code of the crop, along with a section of code known as a **promoter** which would encourage the crop to produce the toxin, and a **marker** which could be used to track and identify modified crop, *e.g.*, *Bt*-cotton, Bt-brinjal.

New Terms Related with Biotechnology

- **Biochips** DNA chips single stranded DNA chains or repetitive DNA segments fierily struck to silica glass chip.
- **Bioinformatics** An interdisciplinary field which addresses biological problems using computational techniques and makes the rapid organization and analysis of biological data possible.
- **Blue biotechnology** An application of biotechnology in the marine and aquatic, but rarely used.
- **Green biotechnology** It is an application of biotechnology in the agricultural processes.
- **Red biotechnology** It is an application of biotechnology in the medical processes.
- **White biotechnology** It is a branch of biotechnology applied to industrial processes.
- **Biomarkers** (Biosignature) is use specific proteins produced during a disease to diagnose disease.
- Genetic engineering or genetic manipulation involves the introduction of foreign DNA or synthetic genes into the organism of interest so as to obtain desired product.
  e.g., Golden rice is variety of *Oryza sativa* produced through genetic engineering to biosynthesize β-carotene, a precursor of pro vitamin-A in the edible parts of rice. Two β-carotene biosynthesis gene were transformed.
  (a) *psy* (phytoene synthase) from daffodil.
  (b) *crt* I from soil bacterium *Erwinia uredovora*.
- Later on other modification were also developed golden rice is expected to reach market by the year 2013.
- Restriction endonucleases enzyme discovered by Nathan and Smith.

Antibiotics

- Monoclonal antibodies are pure antibodies of only one type of B-cell that clones itself by hybridoma technique.
- **Humulin** is human insulin produced through genetic engineering.
- Microbes or their product that can either inhibit or kill other microbe/microbes are called antibiotics.
- Penicillin was discovered by Alexander Fleming.

Microbial Antibiotics

Antibiotics	Source
Penicillin	*Penicillium* notatum, *P. chrysogenum*
Streptomycin	*Streptomyces griseus*
Neomycin	*Streptomyces fradiae*
Tetracycline	*Streptomyces erythraeus*

Fermentation

- Fermentation is the conversion of carbohydrates to alcohol and carbon dioxide or organic acids using yeasts, bacteria or a combination thereof, under anaerobic conditions.
- *Saccharomyces cerevisiae* used in baking and alcohol industry.
- Cheese is formed by the process of coagulation of casein by enzyme rennin.
- Yoghurt is produced by fermentation using *Lactobacillus* and *Streptococcus*.

Different types of fermentations

End Product	Starting Material	Microorganism
Ethanol	malt, grapes	*Saccharomyces sp.*
Acetic acid	Ethanol	*Acetobacter*
Lactic acid	Milk	*Lactobacillus, Streptococcus*
	Grain, sugar	*Lactobacillus bulgaricus*
	Cabbage	*Lactobacillus plantarum*
Propionic acid (Swiss cheese)	Milk	*Propionibacterium freudenrichii*
Citric acid	Molasses	*Aspergillus*

Biogas

- It is the gas produced by biological breakdown of organic matter in the absence of O_2.

- Organic waste such as dead plant and animal material, animal dung and kitchen waste can be converted into gaseous fuel called biogas.
- Biogas comprises primary methane (CH_4) and CO_2 and may have small amounts of hydrogen sulphide (H_2S).
- Moisture and siloxanes.
- Biogas is also called lanfill gas (LFG) or digester gas.

Composition of Biogas

Compound	Percentage
CH_4	50-75
CO_2	25-50
N_2	0-10
H_2	0-1
H_2S	0-3
O_2	0-.5

Exercise

1. Match List I (crops) with List II (Name of the high yielding variety), and select the correct answer using the codes given below the lists.

List I	List II
A. Maize	1. Arjun
B. Paddy	2. Jaya
C. Wheat	3. Ranjit

Codes

	A	B	C		A	B	C
(a)	1	2	3	(b)	2	3	1
(c)	3	2	1	(d)	3	1	2

2. ELISA test is prescribed for
(a) cancer (b) typhoid
(c) polio (d) AIDS

3. Which of the following tests helps in diagnosis of cancer?
(a) X-Ray (b) Urine test (c) Blood test (d) Biopsy

4. Nitrogen fixation is done by
(a) red algae (b) green algae
(c) brown algae (d) blue-green algae

5. The credit of the discovery of antibiotic 'penicillin' goes to
(a) JH Tijo (b) Alexander Fleming
(c) Hargobind Khurana (d) Robert Hooke

6. The oral polio vaccine was discovered by
(a) Louis Pasteur (b) Robert Koch
(c) Jonas Salk (d) Alexander Fleming

7. Restriction enzymes are those enzymes that can
(a) cut RNA (b) cut single stranded DNA
(c) cut double stranded DNA (d) hydrolyse proteins

8. The first successful heart transplantation in India was performed by
(a) Dr. Venugopal (b) Dr. Carali
(c) Dr. Padmawati (d) Dr. Dastur

9. Which of the following pairs is / are correctly matched?
I. Homeopathy — Hahnemann
II. Insulin — Banting
III. Blood transfusion — Harvey
(a) I only (b) I and II (c) II and III (d) I, II and III

10. What is mixed farming?
(a) Cultivating different crops in the same farm
(b) Cultivating different crops alternatively
(c) Cultivating different varieties of same crop
(d) Cultivating crops and keeping livestock in the same farm

11. The free living soil bacteria which fixes nitrogen
(a) *Azotobacter* (b) *Nitrosomonas*
(c) *Nitrobacter* (d) *Pseudomonas*

12. Match list I with list II and select the correct answer using the codes given below the lists.

List I	List II
A. Sugarcane	1. Quinine
B. *Cinchona*	2. Molasses
C. *Hevea*	3. Iodine
D. Sea kelp	4. Rubber

Codes

	A	B	C	D		A	B	C	D
(a)	2	1	4	3	(b)	4	3	2	1
(c)	1	2	3	4	(d)	2	3	4	1

13. Consider the following.
I. Dolly, the cloned sheep.
II. George and Charlie, the cloned calves.
III. Headless frog.
Which of the above has/have the potential of human cloning for human welfare by passing the legal restrictions and ethical concerns in so far as that without central nervous system or brain, the organism may not technically qualify as an embryo?
(a) I, II and III (b) I and II (c) I only (d) III only

14. Endosulfan, which has been in news these days, is
(a) a pesticide (b) a fertilizer **(CDS 2011 II)**
(c) a sulpha drug (d) an antibiotic

15. Which one among the following industries produces the most non-biodegradable wastes? **(CDS 2011 I)**
(a) Thermal power plants (b) Food processing units
(c) Textile mills (d) Paper mills

16. Which among the following statement about biofertilizers are correct? **(2011 II)**
I. *Azotobacter* is one of the nitrogen fixing bacteria used as a biofertilizer.
II. They have to be applied to the leaves of the plant only.
III. They alter the chemical composition of the soil.
IV. They can be used along with organic fertilizers.

Select the correct answer using the codes given below.
(a) I and IV (b) I, II and IV
(c) II and III (d) I, II, III and IV

17. Which among the following are the most important raw materials for manufacturing of soap? **(CDS 2010 II)**
(a) Fats and caustic alkali (b) Fats and potash
(c) Fats and acid (d) Vegetable oil and potash

18. Chemically silk fibres are predominantly **(CDS 2010 II)**
(a) protein
(b) carbohydrate
(c) complex lipid
(d) mixture of polysaccharide and fat

19. Which one of the following plants is used for green manuring in India? **(CDS 2010 I)**
(a) Wheat (b) Sunnhemp (c) Cotton (d) Rice

20. Which among the following are the major reasons behind preferring eucalyptus tree in the planned forestation process? **(CDS 2010 I)**
I. Plantation grows very fast.
II. Plantation makes the soil more fertile.
III. Wood from eucalyptus tree is easily converted into pulp for paper industry.
Select the correct answer using th code given below.
(a) I and II (b) I and III (c) II and III (d) I, II and III

21. If excess fertilizer is applied to a plant without water, the plant will **(CDS 2010 I)**
(a) be stunted in growth (b) develop modifications
(c) die due to plasmolysis (d) remain unaffected

22. A milkman puts banana leaf in milk jar, because banana leaf **(CDS 2010 I)**
(a) gives a fresh flavour to milk
(b) makes the milk acidic and resistant to yeast
(c) makes the milk basic and resistant to yeast
(d) increases the whiteness of milk

23. Match list I with list II and select the correct answer using the codes given below the lists. **(CDS 2010 I)**

List I	List II
A. Wine	1. Barley
B. Beer	2. Sugarcane juice
C. Whisky	3. Grapes
D. Rum	4. Molasses

Codes

	A	B	C	D		A	B	C	D
(a)	2	1	4	3	(b)	3	4	1	2
(c)	3	1	4	2	(d)	2	4	1	3

24. Consider the following statement about bioremediation. **(CDS 2009 II)**
I. It may be defined as any process that uses microorganisms or their enzymes to return the environment altered by contaminants to its original condition.
II. Bioremediation may be employed in order to attack specific contaminants, such as chlorinated pesticides that are degraded by bacteria. Which of the statements given above is/are correct?
(a) I only (b) II only
(c) I and II (d) Neither I nor II

25. Which one of the following is responsible for converting milk into curd? **(CDS 2008 II)**
(a) Fungi (b) Bacteria
(c) Virus (d) None of these

26. Which one of the following is a major constituent of biogas? **(CDS 2008 II)**
(a) Carbon dioxide (b) Methane
(c) Hydrogen (d) Nitrogen dioxide

27. By using which one of the following techniques, is DNA fingerprinting done? **(CDS 2008 II)**
(a) ELISA (b) RIA
(c) Northern Blotting (d) Southern Blotting

28. Which one of the following is correct? A concrete wall generally **(CDS 2008 II)**
(a) only reflects sound
(b) only absorbs sound
(c) only transmits sound
(d) absorbs and transmits sound

29. In the context of ecology and environment, what does the Red Data Book pertain to?
(a) Details of harmful levels of various pollutants
(b) A complete list of all endangered plants and animals
(c) A description of the consequences of nuclear holocaust
(d) A description of the sociological and psychological consequence of genetically modified plants and animals

30. Which one of the following is not a constituent of biogas?
(a) Methane (b) Carbon dioxide
(c) Hydrogen (d) Nitrogen dioxide

Answers

1. (c)	2. (d)	3. (d)	4. (d)	5. (b)	6. (c)	7. (c)	8. (a)	9. (b)	10. (d)
11. (a)	12. (a)	13. (d)	14. (a)	15. (a)	16. (a)	17. (a)	18. (a)	19. (b)	20. (b)
21. (c)	22. (c)	23. (c)	24. (c)	25. (b)	26. (b)	27. (d)	28. (d)	29. (b)	30. (d)

Hints and Solutions

2. ELISA Test is prescribed for AIDS.

14. Endosulfan is a pesticide belonging to the organochlorine group.

15. Non- biodegradable waste cannot be broken down by other living organisms.

21. If excess fertilizer is applied to a plant without water the plant will die due to plasmolysis.