DRAFT STUDY MATERIAL

AGRICULTURE (808)

CLASS – XII

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Contents

UNIT I : Advance Crop Production

1. Food Production Including Horticulture Crops and It's Importance in The Economy and Nutritional Security

Horticulture:- Horticulture is a branch of agriculture in which deal fruit crops, vegetable crops, ornamental plant, commercial flower, medicinal crops, arometics crops, spices crops, plantation crops, individual tree, shrub, climber and post-harvest management and processing.

Importance of Horticulture Crops:-

1. **Per Unit Area Yield is High:-** As compared to the field crops per hectare yield of horticulture crops is very high.

   From an fruit area of land more yield is obtained e.g. paddy gives a maximum yield of only 30 q/ha, while Banana gives 300 to 500 q/ha, Pine apple 450 q/ha and Grapes 90 - 150 q/ha. In present shortage of food and scarcity of land by growing fruits more food can be produced**.**

2. **High Returns per Unit Area:-** From one unit area of land more income will be obtained e.g. Well kept orchard of apple, grapes and sweet orange can give as much as Rs. 25,000 per ha as net income.
3. **High Employment Generation Per Unit Area:-**As per estimation, if agriculture crops are grown in one hector it gives 143 employment days per year but horticulture crops are far more ahead and it gives 870 employment days per year, and crops like has outstanding figure of employment with 2000 employment days per year.
4. **Best Utilization of Waste Land:** Some fruit crops can offer best utilization of waste land crops like wood apple, custard apple, karonda, litchi, cashew nut, coconut etc. can be grown in such areas.
5. **Raw Material for Industries:** Many industry like canning, wine processing, jam, jelly, preserve, candy, fruit beverage, pickle, drying & dehydration, flower processing etc. are depend on fruit, vegetable and flowers for row material.
6. **Use of Undulating Lands:** Fruit growing can be practiced in places where the gradient is uneven or where the land is undulating and agronomical crops cannot be cultivated. In Konkan region, mango and cashew are cultivated on large scales on hilly and hill back area.
7. **Religious Importance/ Aesthetic value:-**

- Coconut is known as *Kalpavriksha.*
- Banana is called as "Apple of paradise", "Kalpatharu" (plant of virtues) "Tree of paradise" and "Adam's Fig".
- Pipal (*Ficus religiosa*) is known as religious tree of India.
- God Shiva is associated with Beal.
- Goddess Sita is associated with Sita Ashok (*Saraca indica*).
- God Vishnu, Brahma and goddess Sarswati or Laxmi are associated with Lotus (*Nelumbo nucifera*).

- God Budha is associated with Pipal, Banyan (*Ficus benghalensis*) and Sita Ashok.

8. **Medicinal Importance:-** The parts like stem, leaf, flowers, roots and even the fruits of horticulture plants are used to make drugs, chemicals, insecticides, germicides etc. e.g. rose water is used to cure eyes ailments. Similarly saffron is important ingredient of many medicines. Papain is a digestive enzyme, citrus fruit like sweet lime is used for liver ailment, rind of pomegranate and pectin from guava used for stomach upset, bark of arjun trees for heart troubles, neem water for skin irritation and allergies etc.

    - **Triphala:-** It is make from Aonla, baheda and harad.

9. **Reputation generation:-** Crops of horticulture generate reputation of farmer by knowledge and high return value.
10. **Nutritive Value:-** Fruits and vegetables are important part of our dietary, which are rich source of nutrient (carbohydrates, protein, fat, vitamins, minerals, and dietary fiber). Carbohydrates, protein and fat are macronutrients, considered as energy sources. Vitamins and minerals are micro nutrient, play important role in body building. Fibers have several direct and indirect advantages. ICMR, New Delhi, recommends 125g of leafy vegetables, 100g of root and tuber vegetables and 75g of other vegetables (total 300g/day) and 120g of fruits per capita every day for balance diet.

1. Carbohydrates

- Carbohydrate is important and chief source of energy in human diet.
- Carbohydrates are classified in 3 groups.

Carbohydrates

Monosaccharides (Reducing Sugar)	Disaccharides (Non-Reducing Sugar)	Polysaccharides
(Glucose, Fructose and Mannose)	(Sucrose, Lactose and Maltose)	(Starch, Cellulose and saccharin)

- 1g glucose liberates 4.0 calories of energy.
- Daily requirement of carbohydrate is 400-500g per capita.

Fruit Sources		**Vegetable sources**	
Raisins	77.3%	Cassava	38.1%
Apricot (dry)	72.8%	Sweet Potato	28.2%
Date	67.37%	Potato	22.6%
Karonda (dry)	67.1%		
Banana	36.4%		
Bael	30.6%		

2. Proteins

- Proteins are extremely complex nitrogen containing organic compounds. They constitute major part of protoplasm.
- Proteins, not considered to be primary body fuel, are also utilized for the production of organisms.
- Proteins made among 20 amino acids, in which 10 are essential amino acid as they are not synthesized in human body.
- 1 g protein liberates 4.0 calories of energy.
- Daily requirement of protein is 60-70g.

Fruit Sources		Vegetable sources	
Cashew nut	21.20%	Lima Bean	7.9 g/100g
Almond	20.88 %	Pea	7.2 g/100g
Walnut	15.60%	Cow Pea	4.3 g/100g

3. at

- Fat is stored energy sources of our body.
- 1 g fat liberates 9.0 calories of energy.

Fruit Sources		Vegetable sources	
Pecan nut	70.0%	Bengal Gram	1.40 g/100g
Walnut	64.5%	Potato	1.18 g/100g
Almond	58.9%	Small Bitter gourd	1.0 g/100g
Cashew nut	46.9%		
Avocado	22.8%		

4. Vitamins

- Vitamins classified in two group:-

1. Water soluble: Vitamin B complex and Vitamin C.
2. Fat soluble : Vitamin A, D, E and K.

Vitamin-A (Retnol, Carotene)

- Daily requirement is 1.2 mg/day.
- Deficiency symptoms: - Night blindness (Nyetalopia), Xeropthalmia for children, Keratnisation of epithelia cell of eyes.
- Vegetable are rich in 'Vitamin-A' than fruit.
- Carrot, muskmelon, winter squash and leafy vegetables are good source of vitamin-A.
- Carrot provide maximum vitamin-A per unit area.

- Precursor of vitamin-A is carotenoids.

Fruit Sources		Vegetable sources	
Mango	4800 IU	Bathua leaves	113000 IU
Papaya	2020 IU	Colocasia leaves	10278 IU
Persimmon	1710 IU	Turnip green	15000 IU
Date palm	600 IU	Beet leaves	9770 IU

Vitamin-B_1 (Thiamine)

- Daily requirement is 1.2 mg/day.
- Deficiency symptoms: - Beriberi, Muscular weakness, less of weight, Neuritis, loss of appetite and dilation of heart.

Fruit Sources		Vegetable sources	
Cashew nut	630 mg/100g	Palk	0.26 mg/100g
Walnut	450 mg/100g	Pea	0.25 mg/100g
Almond	240 mg/100g		

Vitamin-B_2 (Riboflavin)

- Daily requirement is 1.7 mg/day.
- Deficiency symptoms: - Dry scaly skin, crack in corners of mouth, cracking of lips etc.

Fruit Sources		Vegetable sources	
Bael	1191 mg/100g	Palak	0.56 mg/100g
Papaya	250 mg/100g	Chillies	0.39 mg/100g
Cashew nut	190 mg/100g	Fenugreek leaves	0.31 mg/100g
Pineapple	120 mg/100g		

Vitamin-C (Ascorbic acid)

- Daily requirement is 70 mg/day.
- Deficiency symptoms: - Scurvy.
- Approximately 90% vitamin-C is obtained from fruit and vegetable.

Fruit Sources **Vegetable sources**

Barbados cherry	1400 mg/100g	Drumstick leaves	250 mg/100g
Aonla	600 mg/100g	Coriander leaves	135 mg/100g
Guava	299 mg/100g	Chillies	111 mg/100g
		Broccoli	109 mg/100g

Vitamin-B_3 (Nicotinic Acid)

- Daily requirement is 19 mg/day.
- Deficiency symptoms: - Pellagra, nervous breakdown, stomach and intestinal disorder.

Fruit Sources		**Vegetable sources**	
Litchi	122.5 mg/100g	Palak	3.3 mg/100g
		Amaranths leaves	1.0 mg/100g

Vitamin-B_6 (Pyridoxine)

- Daily requirement is 1.3 mg/day.
- Deficiency symptoms: - Lack of Energy, Decrease in Brain Function, High Levels Of Homocysteine.
- Excellent sources of vitamin-B_6 include summer squash, bell peppers, turnip greens, shiitake mushrooms, and spinach.

Vitamin-B_{12} (Cyanocobalamin)

- Daily requirement is 2.4 µg/ day.
- Deficiency symptoms: - Pernicious anemia (Reduction in RBCs), Autoimmune disorders.
- Vitamin-B_{12} is providing by animal food. It is not found in vegetables and fruits.

Vitamin-D (Cholecalciferol)

- Deficiency symptoms: - Rickets, Pigeon chest in children, Ostcomalacia (adult).
- Vitamin-D is synthesized by the body through sunlight.

Vitamin-E (Tocopherol)

- Daily requirement is 5.0 mg/ day.
- Anti-sterility vitamin.
- Deficiency symptoms: - Degeneration of kidney, Necrosis of liver.
- Sweet corn is rich source of vitamin E.

Vitamin-K (Phylloquinone)

- Anti-morrhagic vitamin.
- Daily requirement is 0.015 mg/ day.
- Deficiency symptoms: - Delayed and faulty coagulation of blood.

5. Minerals

Calcium

- Daily requirement is 500-600 mg/ day.

Fruit Sources		Vegetable sources	
Litchi	0.21%	Agathi	1130 mg/100g
Karonda	0.16%	Cury leaf	813 mg/100g

Iodine

- Daily requirement is 500-600 mg/ day.
- Deficiency of Iodine leads to goiter.
- Onion, garlic, beet, agathi leaves are good source of iodine.

Iron

- Daily requirement is 20 mg/ day.

Fruit Sources		Vegetable sources	
Dry karonda	39.1%	Amaranths leaves	22.9%
Date (Pind)	10.6%		

Phosphorus

- Daily requirement is 20 mg/ day.

Fruit Sources		Vegetable sources	
Almond	0.49%	Amaranths leaves	800 mg/100g
Cashew nut	0.45%	Garlic	187 mg/100g
Walnut	0.38%		

Potassium

- Spinach (605 mg/100g) and amaranths leaves (230 mg/100g) are good source of potassium.

Sodium

- Daily requirement is 4000-6000 mg/ day.
- Celeug, green onion, Chinese cabbage etc. are good source of sodium.

Folic Acid

- Daily requirement is 0.1mg/ day.
- Deficiency symptoms: - Anamia, nervous breakdown and impaired growth.
- Importance for women.
- Green leafy vegetables are good source of folic acid.

6. Fibers

Fiber is comprised of components of plant materials (long chain glucose molecules) that are resistant to human digestive enzymes. Fiber plays an important role in digestion, providing bulk, decreasing bowel transit time, absorbing toxins and cleaning the colon of mucus and undigested food particles. Fiber acts to increase the thickness of the stomach contents which gives a feeling of fullness and slows down the emptying of the stomach.

- Fibers are in two forms — soluble and insoluble.

- Vegetables and fruits are an excellent source of fiber, especially potato (2.2g/100g), broccoli, cabbage, cauliflower, corn, green beans, tomatoes zucchini, fig, guava, apples, bananas, apricots, grapes, peaches, strawberries, etc.
- Maximum dietary fiber found in fig 7g/100g followed by guava (6.9%) in fruit and in vegetable potato have maximum dietary fiber 2.2g/100g.

Practice

1. Define the Horticulture?

2. Write down the per capita recommendation of ICMR for fruit and Vegetables.

3. Write down the deficiency symptoms of Ca, Vitamin-C and Vitamin-A.

4. Describe the role of fiber in our diet.

5. Write down the importance of horticulture.

Fill in the Blank-

1. Rickets diseases is due to……………..

2. Beriberi diseases is due to……………..

3. Per Capita per day Carbohydrate requirement……………

4. 1 g fat liberates ……………….. calories of energy

5. Iron content in Karonda fruit is…………………..

Objective Question

1. Per capita per day vegetable requirement is:-

a. 85g b. 125g c. 100g d. 300g

2. Which one is rich source of fat?

a. Walnut b. Pecannut c. Avacado d. Cashewnut

3. Which one is rich source of Fe?

a. Karonda b. Litchi c. Mango d. Date palm

4. Vegetable is poor source of:-

a. Vitamin b. Carbohydrate c. Fat d. Protean

5. Vit-C found in Barbandes Cherry is:-

a. 600mg/100g b. 1400-1600mg/100g c. 299mg/100g d. 150mg/100g

2. Soil Fertility and Productivity

Soil Fertility:

Soil fertility is the ability of the soil to provide all essential plant nutrients in available forms and in a suitable balance.

Soil productivity:

The capability of soil to produce specified crop yield under well-defined and specified systems of management of inputs and environmental conditions.

Factors Governing Soil Fertility

A. Natural factors

1. **Parent material:-** Fertility of a soil depends on the chemical composition of parent material from which it derived.
2. **Topography:-** Soils on the upper slope are less fertile than the soils on lower slope because high leaching and erosion on upper slope.
3. **Climate:-** In tropical climate decomposition of organic matter is faster than temperate climate. Thus soils of tropical regions are less fertile when compared to temperate region.
4. **Depth of Soil Profile:-** Deep soils are more fertile than the shallow soils and the roots are spread well enough in deep soils than the shallow soils.
5. **Physical Condition of Soil:-** The soil texture and soil structure influence the soil fertility.
6. **Soil Age:-** New soil is more fertile and good in structure than old soil because regular consumption of nutrient and degradation of soil structure by vegetation.
7. **Soil Erosion:-** With soil erosion, the top layer of soil is worn away due to factors such as water, wind and tillage of farmland, its lead to less fertility and poor structure.
8. **Nutrient status in Soil:-**

B. Artificial Factors:-

1. Waterlogging
2. Cropping System
3. Soil pH
4. Soil Microorganisms
5. Organic matter content in Soil
6. Method and time of ploughing

Factors Governing Soil Productivity

1. Soil Fertility
2. Soil Physical condition
3. Soil/Farm Location
4. Market demand of Crops
5. Transportation Facility
6. Weather condition
7. Insect-Pest and Disease Attack

Difference between Soil Fertility and Productivity:

Soil Fertility	**Soil Productivity**
1. It is an index of available nutrient to plants	1. It is used to indicate crop yields.
2. Influenced by the physical, chemical and biological factors of the soil.	2. Depends upon fertility and location.
3. It is the function of available nutrients of the soil.	3. It is the function of soil fertility, management and climate.
4. All fertile soils are not productive.	4. All productive soils are fertile.
5. It is an inherent property of the soil.	5. It is not the inherent property of the soil.
6. It is evaluated by soil testing in laboratory	6.It is evaluated by crop production.

Practice

1. Define the Soil Fertility and Soil Productivity?

2. Write down the difference between Soil Fertility and Productivity?

3. Which factor affect to soil fertility?

4. Which factor affect to soil productivity?

Fill in the Blank-

1. …………… is the ability of the soil to provide all essential plant nutrients in available forms and in a suitable balance.

2. Deep soils are ……………. fertile than the shallow soils and the roots are spread well enough in deep soils than the shallow soils.

3. Soil fertility determine in …………………

Objective Question

1. Capacity of nutrient supply to plant is known as?

a. Soil Productivity b. Soil Fertility c. a & b Both d. Production

2. Per unit production is known as?

a. Soil Productivity b. Soil Fertility c. a & b Both d. Production

3. Which is parental factor?

a. Soil Productivity b. Soil Fertility c. a & b Both d. Production

C. Essential Plant Nutrients, Classification of Plant Nutrients. Role of Function of Essential Plant Nutrients and their Important deficiency Symptoms.

The element is involved directly in the nutrition of the plant quite apart from its possible effects in correcting some unfavourable microbiological or chemical condition of the soil or other culture medium.

Essential plant nutrients:- A total of only 17 elements are essential for the growth and full development of higher green plants according to the criteria laid down by Arnon and Stout (1939). These criteria are:-

1. A deficiency of the given element makes it for the plant impossible to complete its life cycle.
2. The deficiency is specific for the given element and not replaceable by another element.
3. The element is a constituent of an essential metabolite or it is required for the action of an enzyme system.
   - According to Arnon had 16 elements are essential for the growth but Ni is also included in essential elements in 2009.

Classification of Plant Nutrients basis on quantity

1. **Frame work Nutrients/Structural Nutrients: -** Plant nutrient participated in structure development that are called as frame work nutrients.
2. **Macro Nutrient:-** Macro nutrient must be presented in plant tissue in concentration more than 1 mg per gram of dry weight.
   - **i.** **Primary Nutrients:-** Among macro nutrients, Nitrogen, Phosphorus and Potassium are known as primary nutrients which are required in a proper ratio for a successful crop.
   - **ii.** **Secondary Nutrients:-** Next to primary nutrients, there are three elements such as Calcium, Magnesium and Sulphur which are known as secondary nutrients.
3. **Micro Nutrients/Trace Nutrients**:- These are present in plant tissue in concentration of $\leq$ 1mg/gram are called as Micro Nutrients.
4. **Ultra-Micro Nutrients**:- These are present in plant tissue in concentration of < 1 ppb are called as Ultra-Micro Nutrients. Eg:- Mo and Co.
5. **Beneficial Plant Nutrients**:- They are not required by all plants but can promote plant growth and may be essential for several plant species. Eg.:- Sodium (Na), Vanadium (V), silicon (Si) and cobalt (Co)
6. **Quasi essential element:-** Silicon is considered a quasi-essential element for plants because its deficiency can cause various abnormalities with respect to plant growth and development. This term was introduced by Epstein (1999), Epstein & Bloom (2005).

Classification on the basis of mobility of nutrient in the soil:

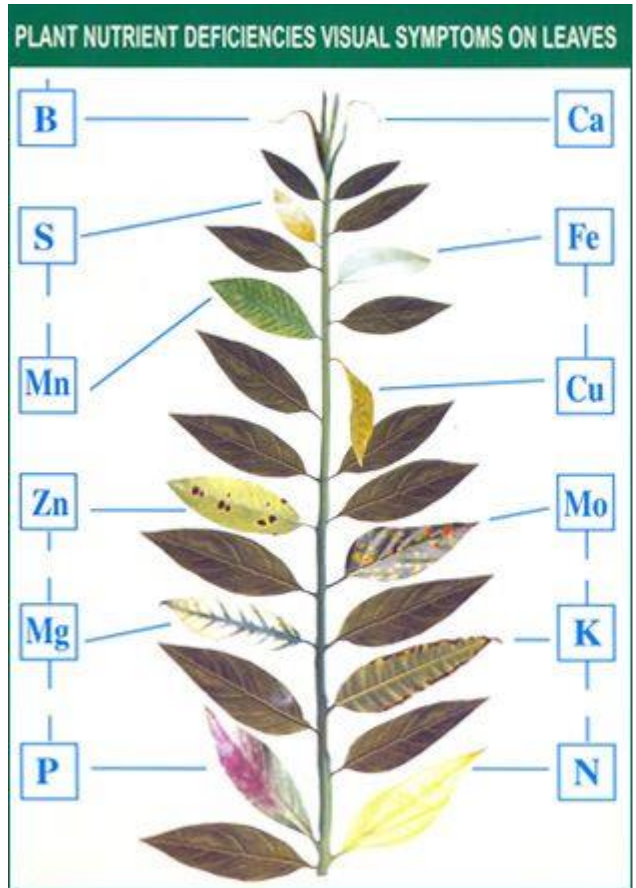
1. **Mobile nutrients:-** The nutrients are highly soluble and these are not adsorbed on clay complexes. Example: NO_3^-, SO_4^{2}-,BO_3^{2-}, Cl^- and Mn^{2+}
2. **Less mobile nutrients:-** They are soluble, but they are adsorbed on clay complex, so their mobility is reduced. Example: NH_4^+, K^+, Ca^+, Mg^{2+}, Cu^{2+}.
3. **Immobile nutrients:-** Nutrient ions are highly reactive and get fixed in the soil. Example: $H_2PO_4^-$, HPO_4^{2-}, Zn^{2+}.

Classification on the basis of mobility with in plant:-

1. **Highly mobile:-** N, P and K.
2. **Moderately mobile:-** Zn
3. **Less mobile:-** S, Fe, Mn, Cl, Mo and Cu
4. **Immobile:-** Ca and B

Plant Nutrient, Chemical Symbol, Uptake Form, Plant Tissue Concentration

Nutrient	Chemical Symbol	Principal forms for uptake	Source	Plant tissue concentration	Plant tissue concentration
1. Basic Nutrients/Frame Work Nutrients					
Carbon	C	CO_2	Air	45.0%	450000ppm
Hydrogen	H	H_2O	Water	6.0%	60000ppm
Oxygen	O	H_2O, O_2	Air/ Water	45.0%	450000ppm
2. **Macro Nutrients**					
a. Primary Nutrients					
Nitrogen	N	NH^+_4, NO^-_3	Soil	1.4%	14000ppm
Phosphorus	P	$H2PO^-_4$, HPO^{2-}_4	Soil	0.1%	1000ppm
Potassium	K	K^+	Soil	1.0%	10000ppm
b. Secondary Nutrients					
Calcium	Ca	Ca_2^+	Soil	0.5%	5000ppm
Magnesium	Mg	Mg_2^+	Soil	0.2%	2000ppm
Sulfur	S	SO^{2-}_4, SO_2	Soil	0.1%	1000ppm
Micro-Nutrients					
Iron	Fe	Fe^{2+}, Fe^{3+}	Soil	0.01%	100ppm
Manganese	Mn	Mn^{2+}	Soil	0.005%	50ppm
Boron	B	H_3BO_3	Soil	0.002%	20ppm
Zinc	Zn	Zn^{2+}	Soil	0.002%	20ppm
Copper	Cu	Cu^{2+}	Soil	0.0006%	6ppm
Molybdenum	Mo	MoO^{2-}_4	Soil	0.00001%	0.1ppm
Chlorine	Cl	Cl^-	Soil	0.01%	100ppm
Nickle	**Ni**	Ni_2^+	Soil		
3. **Beneficial Plant Nutrients**					
Cobalt	Co	Co^{2+}	Soil		
Vanadium	V	V^+	Soil		
Sodium	Na	Na^+	Soil		



Silicon	Si	$Si(OH)^4$	Soil		

Nutrient Deficiency Symptoms at Plant

- **Old Leaves:-** N, P, K, Mg, Mo
- **New Leaves:-** Fe, Cu, Cl, S, Mn
- **Old and New Leaves:-** Zn
- **Apical Bud:-** Ca, B

Nutrients function, deficiency and toxicity

Nutrient	Function	Deficiency	Toxicity
N	• N is biologically combined with C, H, O, and S to create amino acids, which are the	• Stunted growth may occur because of reduction in cell division.	• Vigorous vegetative growth coupled with dark green colour.

	building blocks of proteins. Amino acids are used in forming proto-plasm, the site for cell division and thus for plant growth and development. • Since all plant enzymes are made of proteins, N is needed for all of the enzymatic reactions in a plant. • N is a major part of the chlorophyll molecule and is therefore necessary for photosynthesis. • N is a necessary component of several vitamins. • N improves the quality and quantity of dry matter in leafy vegetables and protein in grain crops.	• Pale green to light yellow colour (chlorosis) appearing first on older leaves, usually starting at the tips. • Depending on the severity of deficiency, the chlorosis could result in the death and/or dropping of the older leaves. This is caused by the translocation of reduced yield. • Plants more susceptible to weather stress and disease. • N deficiency causes early maturity in some crops, which results in a significant reduction in yield and quality.	• The vegetative growth is prolonged and crop maturity is somewhat delayed. • Crop logging.
P	• Typically concentrated in the seeds of many plants as phytin. • Important for plant development including: − development of a healthy root system − normal seed development − uniform crop maturation − photosynthesis, respiration, cell division, and other processes • Essential component of Adenosine Triphosphate (ATP), which is directly responsible for energy transfer reactions in the plant. • Essential component of DNA and RNA, and phospholipids, which play critical roles in cell membranes.	• Because P is needed in large quantities during the early stages of cell division, the initial overall symptom is slow, weak, and stunted growth. • P is relatively mobile in plants and can be transferred to sites of new growth, causing symptoms of dark to blue-green coloration to appear on older leaves of some plants. Under severe deficiency, purpling of leaves and stems may appear. • Plants are stunted and show purple tints on their dark green leaves, veins and stems. • Lack of P can cause delayed maturity and poor seed and fruit development.	• The excess of phosphorus appears mainly in the form of micronutrient deficiency mostly for iron, zinc and manganese. • It is an interesting fact that excess phosphorus, however, may also cause typical calcium deficiency symptoms.
K	• Found in ionic form in the cell, rather than incorporated in structure of organic compounds.	• Commonly causes scorching or firing along leaf margins. • Deficient plants grow	As a result of excess potassium, plants show the typical symptoms of magnesium and possibly

	• Responsible for: − regulation of water usage in plants − disease resistance − stem strength • Involved in: − photosynthesis − drought tolerance − improved winter-hardiness − protein synthesis • Linked to improvement of overall crop quality, includinghandling and storage quality.	slowly, have poorly-developed root systems, weak stalks; lodging is common. • Seed and fruit are small and shrivelled. • Plants possess low resistance to disease. • Deficiencies most common on acid sandy soils and soils that have received large applications of Ca and/or Mg.	calcium deficiency due to a cation imbalance in the plant.
Ca	• Ca has a major role in the formation of the cell wall membrane and its plasticity, affecting normal cell division by maintaining cell integrity and membrane permeability. • Ca is an activator of several enzyme systems in pro-tein synthesis and carbohydrate transfer. • Ca combines with anions including organic acids, sulfates, and phosphates. It acts as a detoxifying agent by neutralizing organic acids in plants. • Ca is essential for seed production in peanuts. • Ca indirectly assists in improving crop yields by re-ducing soil acidity when soils are limed.	• Poor root growth: Ca deficient roots often turn black and rot. • Failure of terminal buds of shoots and apical tips of roots to develop, causing plant growth to cease. • Most often occurs on very acid soils where Ca levels are low. • Other deficiency effects such as high acidity usually limit growth before Ca deficiency apparent.	• Excessive calcium content will produce magnesium or potassium deficiency in plants, although this depends on the concentration of these elements. • Nevertheless, it should be mentioned here that so far calcium toxicity symptoms have not been reported for crops under field conditions.
Mg	• Primary component of chlorophyll and is therefore actively involved in photosynthesis. • Structural component of ribosomes, which are required for protein synthesis. • Involved in phosphate metabolism, respiration, and the activation of several enzyme systems.	• Leaves show a yellowish, bronze or reddish color while leaf veins remain green.	Magnesium toxicity are rare and not generally exhibited visibly.
S	• Required for the synthesis of the sulfur-containing amino acids *cystine*, *cysteine*, and *methionin*e, which are essential for protein formation.	• Chlorosis of the longer leaves. • If deficiency is severe, entire plant can be chlorotic and stunted. • Symptoms resemble those	Leaf size will be reduced and overall growth will be stunted. Leaves yellowing or scorched at edges.

	• Involved with: − Development of enzymes and vitamins (Vit-B). − Promotion of nodulation for N fixation by legumes − Seed production chlorophyll formation − Formation of several organic compounds that give characteristic odors to garlic, mustard, and onion. • It is increase oil content in oil seed crops.	of N deficiency; can lead to incorrect diagnoses.	
B	• Essential for: − germination of pollen grains and growth of pollen tubes − seed and cell wall formation − development and growth of new cells in meristematic tissue • Forms sugar/borate complexes associated with the translocation of sugars, starches, N, and P. • Important in protein synthesis.	• Reduced leaf size and deformation of new leaves. • Interveinal chlorosis if deficiency is severe. • May cause distorted branches and stems. • Related to flower and or fruit abortion, poor grain fill, and stunted growth. • May occur on very acid, sandy-textured soils or alkaline soils.	Yellowing of leaf tip followed by necrosis of the leaves beginning at tips or margins and progressing inward. Some plants are especially sensitive to boron accumulation.
Cu	• Cu is essential in several plant enzyme systems involved in photosynthesis. • Cu is part of the chloroplast protein plastocyanin, which forms part of the electron transport chain. • Cu may have a role in the synthesis and/or stability of chlorophyll and other plant pigments. • Cu is helpful in carotien.	• Reduced leaf size. • Uniformly pale yellow leaves. • Leaves may lack turgor and may develop a bluish-green cast, become chlorotic and curl. • Flower production fails to take place. • Organic soils are most likely to be Cu deficient.	Reduced growth followed by symptoms of iron chlorosis, stunting, reduced branching, abnormal darkening and thickening of roots. This element is essential but extremely toxic in excess.
Fe	• Serves as a catalyst in chlorophyll synthesis. • Involved in many oxidation-reduction reactions during respiration and photosynthesis. • Fe is oxygen the carrier	• Interveinal chlorosis that progresses over the entire leaf. • With severe deficiencies, leaves turn entirely white. • Factors contributing to Fe deficiency include imbalance with other metals, excessive soil P levels, high soil pH, wet, and cold soils.	Excess accumulation is rare but could cause bronzing or tiny brown spots on leaf surface.
Mn	• Functions primarily as a part of the enzyme systems in plants.	• Interveinal chlorosis. • Appearance of brownish-black specks. • Occurs most often on high	Chlorosis, or blotchy leaf tissue due to insufficient chlorophyll

	• Serves as a catalyst in chlorophyll synthesis along with iron. • Activates several important metabolic reactions (enzymes). • Plays a direct role in photosynthesis.	organic matter soils and soils with neutral to alkaline pH with low native Mn content.	synthesis. Growth rate will slow and vigor will decline.
Zn	• Aids in the synthesis of plant growth compounds and enzyme systems. • Zn is required in the synthesis of tryptophan, which in turn is necessary for the formation of indole ace-tic acid in plants. • Essential for promoting certain metabolic/enzymatic reactions. • Necessary for the production of chlorophyll, carbohydrates, and growth hormones.	• Shortened internodes between new leaves. • Death of meristematic tissue. • Deformed new leaves. • Interveinal chlorosis. • Occurs most often on alkaline (high pH) soils or soils with high available P levels.	Zinc in excess is extremely toxic and will cause rapid death. Excess zinc interferes with iron causing chlorosis from iron deficiency.
Mo	• Required for the synthesis and activity of nitrate reductase; the enzyme system that reduces NO_3^- to NH_4^+ in the plant. • Essential in the process of symbiotic N fixation by *Rhizobia* bacteria in legume root nodules.	• Interveinal chlorosis. • Wilting. • Marginal necrosis of upper leaves. • Occurs principally on very acid soils, since Mo becomes less available with low pH.	Excess may cause discoloration of leaves depending on plant species. This condition is rare but could occur from accumulation by continuous application. Used by the plant in very small quantities.
Cl	• Involved in: − energy reactions in the plant − breakdown of water − regulation of stomata guard cells − maintenance of turgor and rate of water loss − plant response to moisture stress and resistance to some diseases − Activates several enzyme systems. • Serves as a counter ion in the transport of several cations in the plant.	• Chlorosis in upper leaves. • Overall wilting of the plants. • Deficiencies may occur in well drained soils under high rainfall conditions.	Burning of leaf tip or margins. Bronzing, yellowing and leaf splitting. Reduced leaf size and lower growth rate.
Co	• Essential in the process of symbiotic N fixation by *Rhizobia* bacteria in legume root nodules. • Has not been proven to be essential for the growth of all	• Causes N deficiency: chlorotic leaves and stunted plants. • Occurs in areas with soils deficient in native Co.	

	higher plants.		
Ni	• Component of the urease enzyme. • Essential for plants supplied with urea and for those in which ureides are important in N metabolism.	• Symptoms and occurrence are not well documented but may include chlorosis and necrosis in young leaves and failure to produce viable seeds.	
V	• The role of vanadium in green plants. Vanadium, although essential for growth and chlorophyll formation in unicellular green algae, reveals toxic influences on cell division of Chlorella pyrenoidosa, these disturbances arising in the same range of V-concentrations as the known positive effects of the trace metal.		
Na	• Sodium is involved in osmotic (water movement) and ionic balance in plants. • It is helpful in tuberization of potato.		
Si	• Direct stimulation of plant growth and yield through more upright growth and plant rigidity. • Suppression of plant diseases caused by bacteria and fungi (such as powdery mildew on cucumber, pumpkin, wheat, barley; gray leaf spot on perennial ryegrass; leaf spot on Bermuda grass; rice blast) • Improved insect resistance (such as suppression of stem borers, leaf spider mites, and various hoppers) • Alleviating various environmental stresses (including lodging, drought, temperature extremes,		

	freezing, UV irradiation) and chemical stresses (including salt, heavy metals, and nutrient imbalances) • Silicon is an important element for animals where it strengthens bones and connective tissue		

Practice

Multiple Choice Question

1. Beneficial nutrient theory given by:-
a. Arnon) b. Satrtut c. Nicolsan d.DeCandoli
2. Ni considered as a essential plant nutrient in year:-
a. 2010 b. 2011 c. 1999 d. 2000
3. Yellowing diseases in tea is due to deficiency of:-
a. Ca b. Zn c. S d. B
4. Which plant nutrients deficiency seen on apical bud of plant?
a. N b. Fe c. Ca d. Mg
5. Which one is Secondary plant nutrients?
a. N b. C c. Mg d. Zn
6. Which one is beneficial plant nutrients?
a. N b. C c. Mg d. Zn
7. Which nutrients is oxygen carrier?
a. B b. Fe c. Ca d. Mg
8. Crop logging is due to toxicity of:-
a. N b. C c. Mg d. Zn

Fill in the Blank

1. ………………..nutrient is known as osmotic agents.
2. ……,…………and ……….are primary nutrients.
3. ………… has a major role in the formation of the cell wall membrane.
4. ……….. is essential component of DNA and RNA, and phospholipids.
5. ……….and …………….are major part of the chlorophyll molecule and is therefore necessary for photosynthesis.

Descriptive questions

1. Describe the essential plant nutrients theory.
2. Write down the deficiency symptoms of Nitrogen, Calcium and Iron.
3. Write down the function of Phosphorus, Magnesium and Zinc.
4. Write down the Classification of plant nutrients on the basis of mobility?
5. Write down the function, deficiency symptoms and toxicity of Potash in plant.

3 Soil Sampling and It’s Processing. Introduction of Soil pH and Organic Carbon

1. **Introduction:** In present days everybody is talking about the soil testing and soil health card distribution. But if we see the common farmers, they have a very little idea about the soil sampling, testing and its profitable practical benefits in their field. Some of them are also wish to test their soils, but they have so many questions in mind likes where to take samples, how to take samples, how much number of samples should collect for a particular area, what should be the depth of sampling, period/interval of soil testing, where the soil can be tested etc. So, for the successful soil testing programme, there are four important phase likes collection of soil samples, analysis of soil samples, interpretation and recommendation, and should be followed strictly.
2. **Collection of Soil Samples:** Soil sampling is the most challengeable task, as a few grams of soil sample represents for a given area. Thus, the soil samples are required to be taken in such a manner that the collected sample should reflect the true fertility of soil for any targeted area. If the field is levelled and soil appears to be uniform, only one composite sample if taken properly could be enough for an area of 4-5 ha. Variation in slope, colour, texture, crop growth, unusual spots and management practice should be taken into account and separate sets of composite samples must be collected from each such area. Recently fertilized plots, bunds,

channels, marshy tracts and area near trees, wells, cattle dung and compost piles or other non-representative locations must be avoided during the sampling.

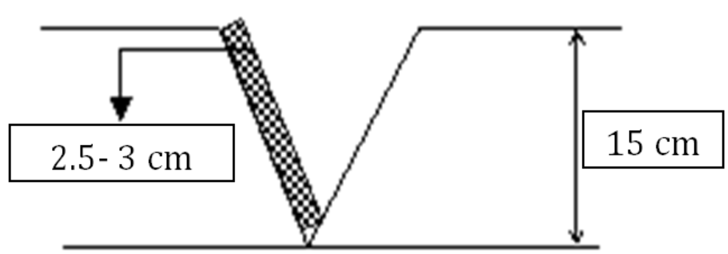
2.1. Sampling Tools: The equipment like; spade/khurpi, auger (tube and screw type), plastic bucket, plastic bag, scale and water proof marker are required for soil sampling. For sampling in the soft and moist soil, the tube auger, spade or khurpi is quite satisfactory. A screw type auger is more convenient on hard/dry land.

2.2. Sampling Depth: The root growth of most of the field crops is confined to 10-20 cm depth and hence sampling upto 15-20cm is enough for the field crops. For most of the pasture crop, 10cm sampling depth is normally sufficient. However, soil samples from the areas growing deep rooted crops like sugarcane, cotton, plantation and horticultural crops are to be collected upto 80-100 cm (90cm) depth.

2.3. Time of Sampling: Soil samples should be collected well before planting/sowing of the targeted crops, so that the soil can be tested in time. If one crop is cultivated in a year, then soil testing once in a three year is sufficient. But under intensive cultivation, say 2-3 crops in a year, then sampling should preferably be done every year prior to sowing of the first crop of the given cropping sequence.

2.4. Methods of Sampling: The greatest source of error in soil analysis is usually the soil sample itself. Consequently, soil samples should be taken in a zigzag manner to cover the entire field. At least 10-25 sub samples (cores) are taken randomly and mixed together to make a representative (composite) sample from a uniform field. First the sampling spot from where the sample is to be collected is cleaned with a spade. If a spade or khurpi is used for soil sampling, first a ‘V’ shaped cut is made up to the plough layer (0-15 cm) and then a uniform 2.5cm thick slice is taken out. Collected soil samples are thoroughly mixed on a clean piece of cloth/polythene sheet/ thick paper and the bulk is reduced by the quartering so that about 500g of composite sample is retained and kept in a clean polythene bag. The sample bags should be clean and fixed properly so as to avoid any mix ups during processing.

Process of sample size reduction or quartering method: Sample should be divided into 4 parts by drawing a ‘+’ sign through it. Discard the soils from the opposite corners. Mix remaining soil, divide into 4 parts and again discard from corners.



2.5. Sample Preparation: A sample is spread out on a plastic or a thick brown paper in the shade for drying, because the wet soil samples collected from the field cannot be stored as changes occur with time in storage condition. Sun drying is strictly prohibited and it is preferable to air dry soils at 20-25^{o}C and 20-60% relative. Coarse concretions, stones and pieces of roots, leaves and other under-composed organic residues are taken away. Large lumps of moist soil are broken by hand. After air drying soil samples are crushed gently with a wooden mortar and pestle, and sieved through a 2mm sieve. The material larger than 2 mm is discarded.

2.6. Sample Storage: Care should be taken to send the collected soil samples as soon as possible for analysis. However, until analyzed, processed samples should be stored in polythene bags or plastic containers properly tied and tagged with the sample label.

2.7. Relevant Information about the Sample: A tag should be attached with each sample includes: name of the farmer, address, date of sampling, sampling depth, previous crop(s) grown, etc. Any other relevant information such as intention of analysis, fertilization history, future crop/cropping plan, etc. should also be provided separately. This supporting information helps for precise fertilizer recommendations. Further, the details, crop and yield history, along with the amount and types of fertilizers applied can also be employed to refine the fertilizer recommendation.

3. Possible Benefits for Farmers:

- Alert about the deficiencies and toxic nutrients exist in their own field and get answers how to overcome.
- Identify the areas under problem soil (if any) which limits crop growth and gather knowledge for reclamation.
- Get an idea about fertilizer recommendation and develop their skill in the use of rational/efficient nutrient inputs.
- Practically observe the contribution in yield increase percent to the applied recommended nutrients.

Soil pH

Soil pH comes from a French term meaning the "Power of Hydrogen." It is a measure of hydrogen ion (H^+) and hydroxyl ion (OH^-) concentration in soil. It refers to the acidity (low pH) or alkalinity (high pH) of soil and is measured in pH units.

The pH scale goes from 0 to 14. A pH of seven is neutral. As the amount of H^+ ions in the soil increases, the soil pH decreases, and the soil becomes more acidic. As the amount of OH^- ions in the soil increases, the soil pH increases, and the soil becomes more alkaline. From pH 7 to 0, the soil is increasingly more acidic, and from pH 7 to 14, the soil is increasingly more alkaline or basic.

Using a strict definition, pH is the negative log of H^+ ion activity in a solution. This means the pH values are reported on a negative log scale. So, a one-unit change in soil pH value signifies a 10 fold change in the actual activity or concentration of H^+, and the H^+ activity increases as the pH level decreases.

To put this into perspective, a soil pH 6 has 10 times more H^+ ions than a soil pH 7, and a soil pH 5 has 100 times more H+ ions than a soil pH 7.

Measuring Soil pH:- Soil pH provides various clues about soil properties and is easily determined. The most accurate method of determining soil pH is by a pH meter. A second method which is simple and easy but less accurate then using a pH meter, consists of using certain indicators or dyes.

The Carbon Cycle and Soil Organic Carbon

Carbon and the Carbon Cycle:- Carbon (C) is one of the most common elements in the universe and found virtually everywhere on earth: in the air, the oceans, soil, and rock. Carbon is part of geologic history in rock and especially the ancient deposits that formed coal, oil and other energy sources we use today. Carbon is also an essential building block of life and a component of all plants and animals on the planet. It has unique bonding properties that allow it to combine with many other elements. These properties enable the formation of molecules that are useful and necessary to support life. The role of carbon in living systems is so significant that a whole branch of study is devoted to it: organic chemistry. Carbon that is not tied up in rock or deep in the oceans is constantly changing and moving. This process is called the carbon cycle (Figure 1). Soil holds the largest portion of active carbon on earth. Plants take carbon from the air and convert it to plant tissue, some of which returns to the soil as plant residue.

Agriculture's Role in the Carbon Cycle:- Carbon is critical to soil function and productivity, and a main component of and contributor to healthy soil conditions. Soil management plays a critical role in whether the carbon remains in the soil or is released to the atmosphere. Agricultural practices can impact both the amount and the composition of soil organic carbon and hence also the soil's physical, biological, and chemical condition, the combination of things that defines soil health. Farm practices that affect carbon therefore impact agricultural productivity and resilience (the soil's ability to deal with weather extremes) and the carbon cycle itself.

Importance of Soil Organic Carbon:- While the agricultural sector has the ability to impact the carbon cycle on a large scale, often through the release of carbon, farmers have a vested interest in retaining and increasing soil organic carbon for individual fields because soil and yield tend to improve when the soil organic carbon level increases. Higher soil organic carbon promotes soil structure or tilth meaning there is greater physical stability. This improves soil aeration (oxygen in the soil) and water drainage and retention, and reduces the risk of erosion and nutrient leaching. Soil organic carbon is also important to chemical composition and biological productivity, including fertility and nutrient holding capacity of a field. As carbon stores in the soil increase, carbon is "sequestered", and the risk of loss of other nutrients through erosion and leaching is reduced. An increase in soil organic carbon typically results in a more stable carbon cycle and enhanced overall agricultural productivity, while physical disturbances of the soil can lead to a net loss of carbon into the surrounding environment due to formation of carbon dioxide (CO2).

Management Practices for C Sequestration With agricultural productivity so dependent on soil organic carbon and carbon cycling, how can we best manage fields to enhance soil organic carbon levels while also reducing carbon loss into the atmosphere?

The ability of agricultural fields to sequester carbon (capture and storage of carbon that would otherwise be lost to the environment) depends on several factors including climate, soil type, type of crop or vegetation cover, and management practices. Employing farming practices that reduce disturbance of the soil (less aeration from tillage helps protect carbon), combined with practices that bring additional carbon to the soil, will allow for carbon sequestration over time. Such practices include implementation of conservation tillage (no-till, zone-till, minimum-till, shallow mixing or injection for manure applications), retaining crop residues, including cover crops in crop rotations, adding organic nutrient sources such as manure and compost, and including perennial crops in crop rotations (Table 1). Their implementation may slow or even reverse the loss of carbon from agricultural fields, improve nutrient cycling and reduce nutrient loss.

Management practices that can increase soil organic carbon and reduce carbon loss into the atmosphere.

Management practices	Functions and explanation
Conservation tillage practices	Conservation tillage practices including no-till management aid in storing soil organic carbon, keeping the physical stability of the soil intact. When reduced-till systems are combined with residue management and manure management, soil organic carbon can increase over time.
Crop residue management	Returning crop residue to the soil adds carbon and helps to maintain soil organic matter.
Cover crops	Cover crops can increase soil carbon pools by adding both root and above ground biomass. Covers also reduce the risk of soil erosion and the resulting loss of carbon with soil particles. Cover crops also enhance nutrient cycling and increase soil health over time.
Manure and compost	Adding organic amendments such as manure or compost can directly increase soil carbon, and also result in increased soil aggregate stability. This enhances the biological buffering capacity of the soil, resulting in greater yields and yield stability over time.

Crop selection	Perennial crops eliminate the need for yearly planting and increase soil organic carbon by root and litter decomposition post-harvest. Crops with greater root mass in general add to root decomposition and physically bond aggregates together. Using high residue annual crops can also help reduce net carbon loss from cropping systems.

Different between soil organic matter and soil organic carbon

Soil organic carbon (SOC) is different to organic matter because it refers only to the carbon component of organic compounds. Soil organic matter is difficult to measure directly, so laboratories tend to measure and report soil organic carbon. A conversion factor is available to report soil organic matter when required.

About 58% of the mass of organic matter exists as carbon. So if we know the organic carbon content in a soil we can estimate the amount of organic matter:

Organic matter (%) = total organic carbon (%) x 1.72

While this ratio can vary in different soils, using a conversion factor of 1.72 provides a reasonable estimate of soil organic matter and is suitable for most purposes.

C: N ratio

- The ratio between the nitrogen content in the microbes and in the organic residues and to the carbon content is called as C:N ratio.
- When fresh plant residues are added to the soil they are rich in carbon and poor in N.
- This results in wider C: N ratio (40:1) decomposition of the organic matter in the soil changes to humus resulting in a narrow C: N ratio (10:1).
- When materials high in carbon are added to the soil the microbial population increase due to the plentiful supply of food material.
- A lot of CO_2 is released.
- During this process the micro organisms utilize the soil N for their body build up and there is a temporary block of N.
- When the decomposition of fresh organic residues reaches to the stage where the C: N ratio is 20:1 there is an increase in the availability of N.
- The C: N ratio of cultivated soils ranges from 8:1 to 15:1.
- Average: 10:1 to 12:1.

Practice

Multiple Choice Question

1. Soil sample depth should be taken for agronomy crops?

a. 10 cm b. 15 cm c. 20 cm d. 25 cm

2. pH meter discover by:-

a. SPL Sorensen b. Arnold O. Beckman c. VV Dokuchaev d. All of theses

3. C:N ratio of Indian soil is:-

a. 10:1 b. 15:1 c. 20:1 d. 25:1

4. Soil sample should be dry at temperature?

a. 15-20^{o}C b. 20-25^{o}C c. 40-50^{o}C d. 100^{o}C

Fill in the Blank

1. Organic matter (%) = total organic carbon (%) x …………..

2. Soil pH comes from a French term meaning the……………….
3. About ………% of the mass of organic matter exists as carbon.
4. Soil samples from the areas growing deep rooted crops like sugarcane, cotton, plantation and horticultural crops are to be collected upto ……………cm depth.

Descriptive

1. Write down the process of preparation of soil sample?
2. Explain the pH?
3. Write the Carbon cycle?
4. What is C:N ratio.

5. Introduction of Manure, Fertilizer, Bio Fertilizer, Their Method of Application and Integrated Nutrients Management

Manures and Fertilizers

Manure: It is a well decomposed refuse from the stable and barn yards including both animal excreta and straw or other plant west.

The term manure implies to the any material with the exception of water which when added to the soil makes it productive and promotes plant growth.

Fertilizers:- These are industrially manufactured chemicals containing plant nutrients.

It is an artificial product containing the plant nutrients which when added to soil makes it productive and promotes plant growth.

Difference between Manures and Fertilizers:

Sr No	Characteristics	Manures	Fertilizer
1.	Origin	Plant or animal origin	Chemical synthesized or manufactured

2.	Nature	Organic in nature	Inorganic in nature
3.	Type	Natural product	artificial product
4.	Conc. Of nutrients	less concentrated	More concentrated
5.	Material	Supply organic matter	Supply inorganic matter
6.	Nutrient availability	slowly available	May or may not be readily available
7.	Nutrients	Supply all the primary nutrients including Micronutrient	Supply specific type of nutrients one, two or three. micro nutrients may or may not be present
8.	Effect on Soil Health	Improves physical condition of soil	Do not improve the physical condition of soil
9.	Effect on plant growth	No bad effect when applied in large quantities.	Adverse effect on plant whenever there is deficiency or excessive application

ADVANTAGES OF ORGANIC MANURES

(ii) Organic manure provides all the nutrients that are required by plants but in limited quantities.

(iii) It helps in maintaining C:N ratio in the soil and also increases the fertility and productivity of the soil.

(iv) It improves the physical, chemical and biological properties of the soil.

(v) It improves both the structure and texture of the soils.

(vi) It increases the water holding capacity of the soil.

(vii) Due to increase in the biological activity, the nutrients that are in the lower depths are made available to the plants.

(viii) It acts as much, thereby minimizing the evaporation losses of moisture from the soil.

List of Organic Manures

Manure	**Percentage content**		
	Nitrogen (N)	**Phosphoric acid P_2O5)**	**Potash (K_2O)**
Coir pith	1.20	1.20	1.20
Bird Guano	7-8	11-14	2-3
Blood meal	10-12	1.2	1.0
Press mud	1-1.5	4-5	2-7
Bone meal			
1)Raw bone meal	3-4	20-25	-
2)Steamed bone meal	1-2	25-30	-
Fish meal	4-10	3.9	0.3-1.5
Sheep and Goat Manure	3.0	1.0	2.0

Animal refuse	0.3-0.4	0.1-0.2	0.1-0.3
Cattle dung, fresh	0.4-0.5	0.3-0.4	0.3-0.4
Horse dung ,fresh	0.5 -0.5	0.4-0.6	0.3-1.0
Poultry manure, fresh	1.0-1.8	1.4-1.8	0.8-0.9
Sewage sludge, dry	2.0-3.5	1.0-5.0	0.2-0.5
Sewage sludge, activate dry	4.0-7.0	2.1-4.2	0.5-0.7
Cattle urine	0.9-1.2	trace	0.5-1.0
Horse urine	1.2-1.5	trace	1.3-1.5
Human urine	0.6-1.0	0.1-0.2	0.2-0.3
Sheep urine	1.5-1.7	trace	1.8-2.0
Ash, coal	0.73	0.45	0.53
Ash, household	0.5-1.9	1.6-4.2	2.3-12.0
Ash, wood	0.1-0.2	0.8-5.9	1.5-36.0
Rural compost ,dry	0.5-1.0	0.4-0.8	0.8-1.2
Urban compost ,dry	0.7-2.0	0.9-3.0	1.0-2.0
Farmyard manure ,dry	0.4-1.5	0.3-0.9	0.3-1.9
Filter-press cake	1.0-1.5	4.0-5.0	2.0-7.0
Rice hulls	0.3-0.5	0.2-0.5	0.3-0.5
Groundnut husks	1.6-1.8	0.3-0.5	1.1-1.7
Banana, dry	0.61	0.12	1.00
Cotton plant residues	0.44	0.10	0.66
Maize Husk	0.42	1.57	1.65
Paddy Husk	0.36	0.08	0.71
Tobacco residues	1.12	0.84	0.80
Pigeon pea residues	1.10	0.58	1.28
Wheat Husk	0.53	0.10	1.10
Sugarcane trash	0.35	0.10	0.60
Tobacco dust	1.10	0.31	0.93
Non edible Oil Cakes			
Castor cake	4.3	1.8	1.3
Cotton cake	3.9	1.8	1.6
Karanj cake	3.9	0.9	1.2
Mahua cake	2.5	0.8	1.8
Neem cake	5.2	1.0	1.4
Safflower cake	4.9	1.4	1.2
Edible Oil cakes			
Coconut cake	3.0	1.9	1.8
Groundnut cake	7.3	1.5	1.3
Niger cake	4.7	1.8	1.3
Rape seed cake	5.2	1.8	1.2
Sesame cake	6.2	2.0	1.2

Classification of Manure

Bulky Organic Manures

Concentrated Organic Manures

Farm Yard Manure (FYM)

Farm Yard Manure (FYM):- It refers to the decomposed mixture of dung and urine of farm animals along with litter (bedding material) and left over material from roughages or fodder fed to the cattle.

- FYM contains:- 0.5% N, 0.25% P_20_5 and 0.4% K_20.
- FYM is one of the most important agricultural by products.
- Nearly 50 per cent of the cattle dung production in India today is utilized as fuel and is thus lost to agriculture.

Compost

A mixture of decayed or decaying organic matter used to fertilize soil. Compost is usually made by gathering plant material, such as leaves, grass clippings, and vegetable peels, into a pile or bin and letting it decompose as a result of the action of aerobic bacteria, fungi, and other organisms.

Methods Of Composting:-

1. **The Indian Banglore Method**:- This method of composting was developed at Bangalore in India by Acharya (1939). The method is basically recommended when night soil and refuse are used for preparing the compost.

   The method overcomes many of the disadvantages of the Indore method such as problem of heap protection from adverse weather, nutrient losses due to high winds / strong sun rays, frequent turning requirements, fly nuisance etc. but the time involved in production of a finished compost is much longer. The method is suitable for areas with scanty rainfall.

   In this method, the disadvantages of Indore method are overcome by slowing down the rate of decomposition and avoiding the turnings. The substrates usually composted in this method are town refuse and night soil which are spread in alternate layers of 15 cm and 5 cm in trenches or pits. When the pit is filled to 15 cm above the ground level, it is sealed to prevent loss of moisture. After the initial aerobic decomposition for 8 - 10 days the material undergoes semi anaerobic decomposition. During this stage the rate of decomposition slows down taking about 6 - 8 months for the compost to be ready. Often, the composting period is more than eight months due to high carbon: nitrogen ratio. Loss of organic matter and nitrogen is negligible and percentage recovery of compost is more. But, this method is not adaptable to heavy rainfall areas.
2. **The Indian Indoor Method:-** Sir Albert Howard and Wad (1924-26) at Indore, Madhya Pradesh, developed this method in which the conservation of cattle urine is effected by getting it absorbed in rice straw, straw dust and other organic wastes used as bedding in cattle shed. The urine soaked material along with fresh cow dung serves as major source of nitrogen for the microorganisms involved in composting.

   Raw materials:- The raw materials used are mixed plant residues, animal dung and urine, earth, wood ash and water. All organic material wastes available on a farm, such as weeds, stalks, stems, fallen leaves, prunings, chaff and fodder leftovers, are collected and stacked in a pile. Hard woody material such as cotton and pigeon-pea stalks and stubble are first spread on the farm road and crushed under vehicles such as tractors or bullock carts before being piled. Such hard materials should not exceed 10 percent of the total plant residues. Green materials, which are soft and succulent, are allowed to wilt for two to three days in order to remove excess moisture before stacking; they tend to pack closely when stacked in the fresh state. The mixture of different kinds of organic material residues ensures a more efficient decomposition.

While stacking, each type of material is spread in layers about 15 cm thick until the heap is about 1.5 m high. The heap is then cut into vertical slices and about 20-25 kg are put under the feet of cattle in the shed as bedding for the night. The next morning, the bedding, along with the dung and urine and urine-earth, is taken to the pits where the composting is to be done.

Pit site and size:- The site of the compost pit should be at a level high enough to prevent rainwater from entering in the monsoon season; it should be near the cattle shed and a water source. A temporary shed may be constructed over it to protect the compost from heavy rainfall. The pit should be about 1 m deep, 1.5-2 m wide, and of a suitable length.

Filling the pit:- The material brought from the cattle shed is spread in the pit in even layers of 10-15 cm. A slurry made from 4.5 kg of dung, 3.5 kg of urine-earth and 4.5 kg of inoculum from a 15-day-old composting pit is spread on each layer. Sufficient water is sprinkled over the material in the pit to wet it. The pit is filled in this way, layer by layer, and it should not take longer than one week to fill. Care should be taken to avoid compacting the material in any way.

Turning:- The material is turned three times while in the pit during the whole period of composting: the first time 15 days after filling the pit; the second after another 15 days; and the third after another month. At each turning, the material is mixed thoroughly and moistened with water. It will be ready in four months.

3. **Indian Indore heap method**

   Heap site and size:- During rainy seasons or in regions with heavy rainfall, the compost may be prepared in heaps above ground and protected by a shed. The pile is about 2 m wide at the base, 1.5 m high and 2 m long. The sides taper so that the top is about 0.5 m narrower than the base. A small bund is sometimes built around the pile to protect it from wind, which tends to dry the heap.

   Forming the heap:- The heap is usually started with a 20 cm layer of carbonaceous material such as leaves, hay, straw, sawdust, wood chips and chopped corn stalks. This is covered with 10 cm of nitrogenous material such as fresh grass, weeds or garden plant residues, fresh or dry manure or digested sewage sludge. The pattern of 20 cm of carbonaceous material and 10 cm of nitrogenous material is repeated until the pile is 1.5 m high and the material is normally wetted until it feels damp but not soggy. The pile is sometimes covered with soil or hay to retain heat and it is turned at intervals of 6 and 12 weeks. In the Republic of Korea, the heaps are covered with thin plastic sheets to retain heat and prevent insect breeding.

   Where materials are in short supply, the alternate layers can be added as they become available. Moreover, all the materials can be mixed together in the pile provided that the proper proportions are maintained. Shredding the material speeds up decomposition considerably. Most materials can be shredded by running a rotary mower over them several times. Where sufficient nitrogenous material is not available, a green manure or leguminous crop such as sun hemp is grown on the fermenting heap by sowing seeds after the first turning. The green matter is then turned in at the time of the second mixing. The process takes about four months to complete.

4. **Indian Coimbatore method:-** This method (Manickam, 1967) involves digging a pit (360 cm long × 180 cm wide × 90 cm deep) in a shaded area (length can vary according to the volume of waste materials available). Farm wastes such as straw, vegetable refuse, weeds and leaves are spread to a thickness of 15-20 cm. Wet animal dung is spread over this layer to a thickness of 5 cm. Water is sprinkled to moisten the material (50-60 percent of mass). This procedure is repeated until the whole mass

reaches a height of 60 cm above ground. It is then plastered with mud, and anaerobic decomposition commences. In four weeks, the mass becomes reduced and the heap flattens. The mud plaster is removed and the entire mass is turned. Aerobic decomposition commences in at this stage. Water is sprinkled to keep the material moist. The compost is ready for use after four months.

5. **NADEP method:-** NADEP method of compost making has been developed by a farmer, Narayan Rao Pandhari Pande, in Maharastra, India. This method is based on the principle of aerobic decomposition with natural flow of optimum air. The substrate is converted at the top by plastering with dung and soil to minimise the loss of moisture.
6. **ADCO Method:-** This method of compost making has been developed by Hutchinson and Richards in 1921 in England. In such method ADCO powder use as a starter.
7. **Activated method:-**

Oil Cakes Manure

Many oil cakes such as the castor, neem, madhuca, karanja, linseed, rape seed and cotton seed which are non-edible oil cakes may serve as useful organic manure as these contain high amounts of plant nutrients.

- Most of the non-edible oil cakes are valued much for their alkaloid contents which inhibit the nitrification process in soils.
- Neem cake contains the alkaloids - nimbin and nimbicidine which effectively inhibit the nitrification process.
- Karanjin (Pongamia pinnata) and (*Madhuca butyracea*) is a potent nitrification inhibitor equal in efficiency to nitropyrin inretarding the nitrification process of ammoniacal nitrogen and increasing the yield, nitrogen uptake and grain protein content of rice .
- Madhuca cake has been successfully used in coastal saline soils for cultivatiion of rice.
- Oil cake powder manure use 15 days before sowing.
- Mahua oil cake contains saponin, it is decomposed slowly so 2 months before sowing.

Green Manuring

Green Manuring:- It can be defined as a practice of ploughing or turning into the soil, undecomposed green plant tissues for the purpose of improving the soil fertility. Green manure plant should be turning into soil at flowering stage and 45 days before crop sowing.

- Dhaincha and Sun hemp are mostly used for green manuring.
- Dhaincha can be grown in highly alkali soil.
- Dhaincha plant pH is 5.0-5.2 and Dhaincha juice pH is 4. It is use as a Soil improvers in saline and alkaline soil.
- It is obtained in two ways: by growing green manure crops or by collecting green leaf (along with twigs) from plants grown in wastelands, field bunds and forest.
- Green manuring is growing in the field plants usually belonging to leguminous family and incorporating into the soil after sufficient growth.
- The plants that are grown for green manure known as green manure crops.

Sr.	Green manure	Botanical Name	N%	N Kg/ha	Organic

No.					Matter (t/ha)
1.	Sunhemp	*Crotalaria juncea*	0.43	84	30
2.	Dhaincha	*Sesbania aculeata*	0.42	77	23.2
3.	Sweet clover	*Melilotus indica*	0.51	134	
4.	Black gram	*Vigna mungo*	0.41	38	
5.	Mung bean	*Vigna radiata*	0.53	38	
6.	Cluster bean	*Cyamopsis tetragonoloba*	0.34	62	
7.	Cowpea	*Vigna sinensis*	0.49	56	
8.	Pea	*Pisum sativum*	0.36	66.5	
9.	Lentil	*Lens culinaris*	0.70	36.5	
10	Moth bean	*Vigna aconitifolia*	0.41	42	

Nutrient content of green leaf manure

Plant	**Scientific name**	**Nutrient content (%) on air dry basis**		
		N	**P2O5**	**K**
Gliricidia	*Gliricidia sepium*	2.76	0.28	4.60
Pongania	*Pongamia glabra*	3.31	0.44	2.39
Neem	*Azadirachta indica*	2.83	0.28	0.35
Gulmohur	*Delonix regia*	2.76	0.46	0.50
Peltophorum	*Peltophorum ferrugenum*	2.63	0.37	0.50
Weeds				
Parthenium	*Parthenium hysterophorus*	2.68	0.68	1.45
Water hyacinth	*Eichhornia crassipes*	3.01	0.90	0.15
Trianthema	*Trianthema portulacastrum*	2.64	0.43	1.30
Ipomoea	*Ipomoea*	2.01	0.33	0.40
Calotrophis	*Calotropis gigantea*	2.06	0.54	0.31
Cassia	*Cassia fistula*	1.60	0.24	1.20

Bio-Fertilizer

Biofertilizer are defined as preparations containing living cells or latent cells of efficient strains of microorganisms that help crop plants for the uptake of nutrients by their interactions in the rhizosphere.

Role of Biofertilizers in soil fertility and Agriculture:-

1. They supplement chemical fertilizers for meeting the integrated nutrient demand of the crops.
2. They can add 20-200 kg N/ha year under optimum soil conditions and thereby increases 15-30 percent of total crop yield.
3. They can at best minimize the use of chemical fertilizers not exceeding 40-50 kg N/ha under ideal agronomic and pest-free conditions.
4. Application of Biofertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation.

5. Some Biofertilizers (eg, *Rhizobium* BGA, *Azotobacter sp*) stimulate production of growth promoting substance like vitamin- B complex, Indole acetic acid (IAA) and Gibberellic acids etc.
6.Phosphate mobilizing or phosphorus solubilizing Biofertilizers / microorganisms (bacteria, fungi, mycorrhiza etc.) converts insoluble soil phosphate into soluble forms by secreting several organic acids and under optimum conditions they can solubilize / mobilize about 30-50 kg P2O5/ha due to which crop yield may increase by 10 to 20%.
7.Mycorrhiza or VA-mycorrhiza (VAM fungi) when used as Biofertilizers enhance uptake of P, Zn, S and water, leading to uniform crop growth and increased yield and also enhance resistance to root diseases and improve hardiness of transplant stock. They liberate growth promoting substances and vitamins and help to maintain soil fertility.
8. They act as antagonists and suppress the incidence of soil borne plant pathogens and thus, help in the bio-control of diseases.
9. Nitrogen fixing, phosphate mobilizing and cellulolytic microorganisms in bio- fertilizer enhance the availability of plant nutrients in the soil and thus, sustain the agricultural production and farming system.
10. They are cheaper, pollution free and renewable energy sources.
11. They improve physical properties of soil, soil tilth and soil health in general.
12. They improve soil fertility and soil productivity.
13. Blue green algae like Nostoc, Anabaena, and Scytonema are often employed in the reclamation of alkaline soils.
14. Bio-inoculants containing cellulolytic and lignolytic microorganisms enhance the degradation/ decomposition of organic matter in soil, as well as enhance the rate of decomposition in compost pit.
15. BGA plays a vital role in the nitrogen economy of rice fields in tropical regions. *Azotobacter* inoculants when applied to many non-leguminous crop plants, promote seed germination and initial vigor of plants by producing growth promoting substances.
16. Azolla-Anabaena grows profusely as a floating plant in the flooded rice fields and can fix 40-80 kg N/ha /year in approximately 40-60 tones of biomass produced, Plays important role in the recycling of plant nutrients.

Sr. No.	Examples	Remarks
Symbiotic N_2 Fixing Bio fertilizer		
1.	*Rhizobium*	Symbiosis with Pulses
2.	*Frankia* and *Casuarina sp*	Symbiosis with Non-legume crops like Casuarina
3.	*Anabaena azollae* and *Azolla pinnata*	Symbiosis with Azolla
Associative Symbiotic N_2 Fixing Bio fertilizer		
4.	*Azospirillum*	
Free living N_2 Fixing Bio fertilizer		
5.	*Azotobacter chroccum, Azotobacter vinefandi, Beijernckia, Klebsiella, Anabaena, Nostoc,*	Aerobic Bacteria
6.	*Clostridium*	Anaerobic Bacteria

Sr. No.	Group	Examples
P Solubilizing Biofertilizers		
1.	Bacteria	*Bacillus megaterium* var. *phosphaticum, Bacillus subtili, Bacillus circulans, Pseudomonas striata*

2.	Fungi	*Penicillium sp, Aspergillus awamori*
P Mobilizing Biofertilizers		
1.	Arbuscular mycorrhiza	*Glomus sp.,Gigaspora sp., Acaulospora sp., Scutellospora sp. & Sclerocystis sp.*
2.	Ectomycorrhiza	*Laccaria sp., Pisolithus sp., Boletus sp., Amanita sp.*
3.	Ericoid mycorrhizae	*Pezizella ericae*
4.	Orchid mycorrhiza	*Rhizoctonia solani*
Biofertilizers for Micro nutrients		
1.	Silicate and Zinc solubilizers	*Bacillus* sp.
Plant Growth Promoting Rhizobacteria		
1.	Pseudomonas	*Pseudomonas fluorescens*

Bio-fertilizer:-

Name of Bio fertilizer	Contribution	Beneficiaries
Rhizobium (Symbiotic)	Fix 30-100kg N/ha Leaves residues nitrogen Increase yield by 10-30% Maintains soil fertility	All legume exception Rajamma
Azotobacter	A free living bacteria mostly found in neutral to alkaline soils. Supplies 20-40mg/g of carbon source Performance of growth substance like vitamins 10-15 increase in yield Maintains soil fertility Biological control of plant disease, suppresses plant pathogen	Mustard, sunflower, banana, sugarcane, grapes, papaya, watermelon, tomato, chilli, okra, coconut, spices, flower plants etc.
Azospirillum	Fixes 20-40 kg N/ha Result in increased minerals and water uptake Root development PGRs production (IAA), disease resistance and drought tolerance are some of the additional benefits	Rice, Sugarcane, Pearmillet, wheat, sorghum etc
Blue Green Algae	Fix 20-30kg/N/ha Result in increased minerals and water uptake Produce substance like Auxin and GA_3	Rice
Azolla	Fix 40-80kg/N/ha Play role as a green manure	Rice

	because it produce large mass	

Phosphate solubilizing Biofertilizer

- Group of beneficial bacteria capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds
- Pseudomonas, Bacillus and Rhizobium are among the most powerful inoculation of PSB- 30 kg P_2O_5 /ha

Mycorrhiza

- A symbiotic generally mutualistic association between a fungus and the roots of a vascular plant.
- The fungus colonizes the host plant's roots, either intracellularly or extracellularly.
- This association provides the fungus with access to carbohydrates.
- In return, the plant gains the benefits of the mycelium's higher absorptive capacity for water and mineral.
- Plant roots alone may be incapable of taking up phosphate ions that are demineralized in soils with a basic pH.
- The mycelium of the mycorrhizal fungus can make them available to the plants they colonize. Mycorrhizal and non-mycorrhizal barley plants after colonization with *Cochliobolus sativus* (Kogel, Giessen) nutrients carbohydrates Stress resistance Benefit for both partners

Silicate and Zinc solubilizing Biofertilizer

- Microorganisms are capable of degrading silicates and aluminum silicates.
- Bacillus sp can be used as bio-fertilizer for zinc or aluminum silicates because these organisms solubilize the zinc present in the soil and make it available to the plants.
- Plant Growth Promoting Rhizobacteria (PGPR).
- Species of Pseudomonas and Bacillus can produce phytohormones or growth promoters.
- They produce include indole-acetic acid, cytokinins, gibberellins and inhibitors of ethylene production

Methods of Bio fertilizer Application:-

1. **BGA(Rice):-** Soil Application @4kg algal culture/ac at 7DAT
2. **Azolla(Rice):-** As Green Manure (4t/ac) at planting. As Dual Crop/inter crop (400-500kg/ac) at 7DAT
3. ***Rhizobium* (all legumes):-**
   - Treatment Seed
   - Soil Application
4. ***Azotobacter* and *Azospirillum* (all non-legumes):-**
   - Seed treatment
   - Seed material treatments (potato/sugarcane/sweet potato etc.)
   - Seedling Root dipping (vegetables/flowers those are transplanted)
   - Soil application
5. **PSM/ Phosphorus Solubilizer Microorganism (all legumes and non-legumes):-**
   - Seed treatment
   - Seed material treatment(potato/sugarcane/sweetpotato etc.)
   - Seedling Root dipping (vegetables/flowers those are transplanted)
   - Soil application
6. **VAM (Vescicular Arbuscular Mycorrhiza):-**
   - Inoculation of seedlings on the seedbed
   - Inoculation of potted soil Waste Decomposers

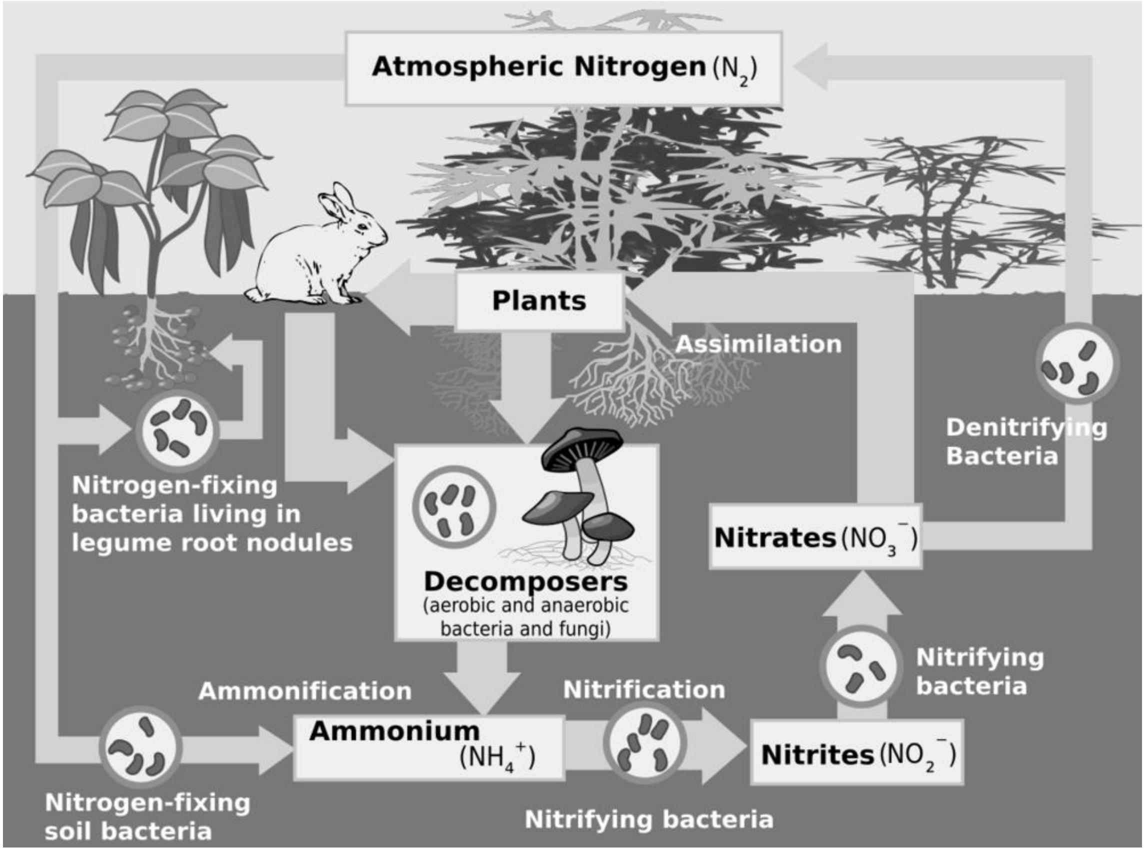
- ➢ Compost pit decomposition
- ➢ Field(in situ) decomposition

✓ The name Rhizobium was established by Frank in 1889.

Rhizobium bacteria and its groups

Host Group	***Rhizobium* Species**	**Crops**	**N fix kg/ha**
Pea group	*Rhizobium leguminosarum*	Pea, Lentil, Vicia (Vetch), Lathyrus (sweet pea)	62- 132
Soybean group	*R.japonicum*	Soybean, Cowpea, Groundnut, Sunhemp, Moong	57- 105
Lupini Group	*R. lupine orinthopus*	Lupinus, Ornithopus	70- 90
Alfafa grp.Group	*R.melliloti*	Melilotus (Sweet Clover), Medicago (Alfa-Alfa), Trigonella (Fenugreek)	100- 150
Beans group	*R. phaseoli*	Phaseoli	80- 110
Clover group	*R. trifoli*	Trifolium	130

Nitrogen fixation:- The nitrogen cycle is the biogeochemical cycle by which nitrogen is converted into various chemical forms as it circulates among the atmosphere and terrestrial and marine ecosystems. The conversion of nitrogen can be carried out through both biological and physical processes.



Nitrifying bacterium, plural Nitrifying Bacteria, any of a small group of aerobic bacteria (family Nitrobacteraceae) that use inorganic chemicals as an energy source. They are microorganisms that are important in the nitrogen cycle as converters of soil ammonia to nitrates, compounds usable by plants. The nitrification process requires the mediation of two distinct groups: bacteria that convert ammonia to nitrites (*Nitrosomonas, Nitrosospira, Nitrosococcus, and Nitrosolobus*) and bacteria that convert nitrites (toxic to plants) to nitrates (*Nitrobacter, Nitrospina, and Nitrococcus*).

Denitrifying bacteria, microorganisms whose action results in the conversion of nitrates in soil to free atmospheric nitrogen, thus depleting soil fertility and reducing agricultural productivity. *Thiobacillus denitrificans*, *Micrococcus denitrificans*, and some species of *Serratia*, *Pseudomonas*, and *Achromobacter* are implicated as denitrifiers. *Pseudomonas aeruginosa* can, under anaerobic conditions (as in swampy or water-logged soils), reduce the amount of fixed nitrogen (as fertilizer) by up to 50 percent.

Sr.No.	Crops	Fix N/kg/ha
1.	Alfalfa	194
2.	Ladino Clover	179
3.	Sweet clover	119
4.	Red clover	114
5.	Kudzu	107
6.	White clover	103
7.	Cowpea	90
8.	Vetch	80
9.	Peas	72
10.	Soya been	58

11.	Peanuts	42
12.	Beans	40

Integrated nutrient management (INM)

1. Introduction:- Integrated nutrient management (INM) is not a new concept. It is an age-old practice when almost all the nutrient needs were met through organic sources to supply secondary and micronutrients besides primary nutrients. In scientific literature, a few terminology variants like integrated plant nutrient supply (IPNS) and integrated nutrient supply and management (INSAM) are also used to convey almost similar meaning as that of INM.

2. INM/IPNS Definitions:- INM or IPNS has been defined by different researchers as follows: IPNS is defined as maintenance or adjustment of soil fertility and supply of plant nutrient to an optimum level for sustaining the desired crop productivity through optimization of benefit from all possible resources of plant nutrients in an integrated manner. IPNS is used to maintain or adjust soil fertility and plant nutrient supply to achieve a given level of crop production. This is done by optimizing the benefits from all possible sources of plant nutrients. The basic concept of INM is the maintenance and improvement of soil fertility through integrating various nutrient resources along with fertilizers for sustaining crop productivity on long-term basis.

The concept includes key areas like, maintenance/adjustment of soil fertility, optimum plant nutrient supply, sustaining desired level of productivity, optimization of benefits from all possible sources of nutrients and addressing environmental concerns. This may be achieved through combined use of all possible sources of nutrients and their scientific management for optimum growth, yield and quality of different crops and cropping systems.

This concept of nutrient management assumed greater significance in recent years because of two reasons. First, the need for continued increase in agricultural production and productivity requires growing application of nutrients and the present level of fertiliser production in India is not enough to meet the entire plant nutrient requirement. The impending demand-supply gap of about 10 million tonnes of plant nutrients is likely to widen further in view of steep hike in the prices of P&K fertilisers and raw materials. Second, a large number of experiments on INM, particularly long-term experiments (LTEs) conducted in India or elsewhere reveal that neither the fertilisers nor the organic sources in isolation can achieve sustained production under intensive cropping. Even the so called balanced use of fertilisers will not be able to sustain high productivity due to emergence of secondary or micronutrient deficiencies over time. The interactive advantages of combining organic and inorganic sources of nutrients in INM have proved superior to the sole use of these sources.

3. Components of INM:- Fertilisers, organic manures, legumes, crop residues, and bio-fertilisers are the main ingredients of INM**.**

3.1. Fertilisers:- Fertilisers continued to be the most important ingredient of INM. The dependence on fertilisers has been increasing constantly because of the need to supply large amounts of nutrients in intensive cropping with high productivity. Nonetheless, fertiliser consumption is not only inadequate but also imbalanced.

The $N:P_2O_5:K_2O$ use ratio is quite wide whereas application of K, S and micronutrients is often ignored. Domestic fertilizer production is inadequate to meet the requirements and the situation is not likely to improve in the near future. On the other hand, constraints like global price hike of fertilisers and raw materials would not permit fertiliser import in large quantities leading to a big gap between fertiliser supply and consumption. While organics and biofertilisers are expected to bridge a part of this gap, efficient use of fertilisers in narrowing the nutrient supply gap also needs greater emphasis. Utilization of fertiliser nutrients by the crops vary from 30-50% in case of N, 15- 20% in case of P and less than 5% in case of micronutrients. Thus substantial amount of applied nutrients is lost through various pathways. Enhancing nutrient use efficiency should, therefore, be a prioritized area of research for restoration and improvement of soil health and minimising the cost of crop production.

3.2. Organic Manures:- Organic manures like urban compost, FYM, crop residues, human excreta, city refuse, rural compost, sewage-sludge, pressmud and other agroindustrial wastes have large nutrient potential. Compost and FYM have traditionally been the important manures for maintaining soil fertility and ensuring yield stability. Other potential organic sources of nutrients such as non-edible oilcakes and wastes from food processing industry are also there. Moreover, there are several industrial by-products and municipal wastes with fair nutrient potential. However, these nutrient-carriers have not been properly evaluated to establish their fertiliser equivalents. There is need to integrate these sources depending on their availability in different crops and cropping systems. The industrial byproducts like spent-wash from distillery, molasses, pressmud, etc., from sugar industry and wastes from other food processing industries have good manorial value. Sulphitation pressmud (SPM) has a great potential to supply nutrients in addition to favourable effects on soil properties. During the last three decades, SPM has assumed great importance as a nutrient supplement in sugarcaneratoon- wheat and other intensive cropping systems of the sugarcane growing areas. Municipal solid wastes (MSW) and sewage-sludge are the other important nutrient sources available for integration with fertiliser inputs, though these have to be used with caution to avoid any potential threat of pathogens and heavy metal load. These nutrient sources are bulky in nature with low nutrient content and short in supply; hence, have lost their relative importance over time in crop production. However, cost of fertilisers and their limited supply made it necessary to search for alternative and renewable sources of plant nutrients leading to major interest in organic recycling. Less than 50% of the manurial potential of cattle dung is utilized at present, as large proportion is lost as fuel and droppings in non-agricultural areas. Out of the cattle dung and other farmyard wastes recycled lack to the soil as manure, substantial nutrients are lost due to faulty methods of manure preparation and its amount of application. Organic manures not only supply macro and micronutrients, but also help improving the physical, chemical and biological properties of the soils. These manures, besides supplying nutrients to the first crop, also leave substantial residual effect on succeeding crops in the system.

3.3. Legumes:- Legumes have a long-standing history of being soil fertility restorers due to their ability to obtain N from the atmosphere in symbiosis with Rhizobia. Legumes could prove an important ingredient of INM when grown for grain or fodder in a cropping system, or when introduced for green manuring. Legumes grown as green manure, forage or grain crops improved the productivity of rice-wheat cropping system (RWCS) and rejuvenated soil fertility.

3.4. Crop Residues:- Crop residues have several competitive uses and may not be always available as an ingredient of INM, yet in the regions like North-West India where mechanical harvesting is practiced, a sizeable quantity of residues is left in the field, which can form a part of nutrient supply. There are large amounts of residues of other crops like, potato, sugarcane, vegetables, etc., which are practically wasted in most cases.Although cereal crop residues are valuable cattle-feed, these could be used to supplement the fertilisers wherever available in excess of the local needs.Disposal of rice straw in Trans- and Upper Gangetic Plains has emerged as a great problem. In these combine-harvested areas farmers opt to burn the residues in situ, losing precious nutrients on one hand and polluting environment on the other. Recycling of these residues back to fields helps to build stable organic matter in the soil, as also to sustain crop yield levels. Stubbles left in the field even in traditional harvesting methods range from 0.5 to 1.5 t/ha in case of different crops. When mechanical harvesting is done, this amount is much greater. Stubbles of coarse cereals such as sorghum, maize, pearl millet, etc., which are difficult to decompose are normally collected and burnt during land preparation causing significant loss of plant nutrients.

3.5. Biofertilisers:- Biofertilisers are the materials containing living or latent cells of agriculturally beneficial microorganisms that play an important role in improving soil fertility and crop productivity due to their capability to fix atmospheric N, solublize/mobilize P and decompose farm waste resulting in the release of plant nutrients. The extent of benefit from these microorganisms depends on their number and efficiency which, however, is governed by a large number of soil and environmental factors. Bacterial cultures like *Rhizobium, Azospirillium* and *Azotobacter* have the ability to fix atmospheric N which in turn increase N supply to the crops. Bacterial cultures of *Pseudomonas* and *Bacillus* species and fungal culture of *Aspergillus* species help to convert insoluble P into plant usable forms and thus improve phosphate availability to the crops. Similarly, fungi like Vesicular Arbuscular Mycorrhizae (VAM) increase nutrient uptake particularly that of P due to increased contact of roots with larger soil volume. *Rhizobium* is the most well-known bacterial species that acts as the primary symbiotic fixer of N. These bacteria can infect the roots of leguminous plants, leading to the formation of lumps or nodules where the N fixation takes place. The bacterium's enzyme system supplies a constant source of reduced N to the host plant and the plant furnishes nutrients and energy for the activities of the bacterium. The Rhizobium-legume association can fix up to 100-300 kg N/ha in one crop season and in certain situations leave substantial N for the following crop. This symbiosis can meet more than 80% of the N requirement of the legume crop.

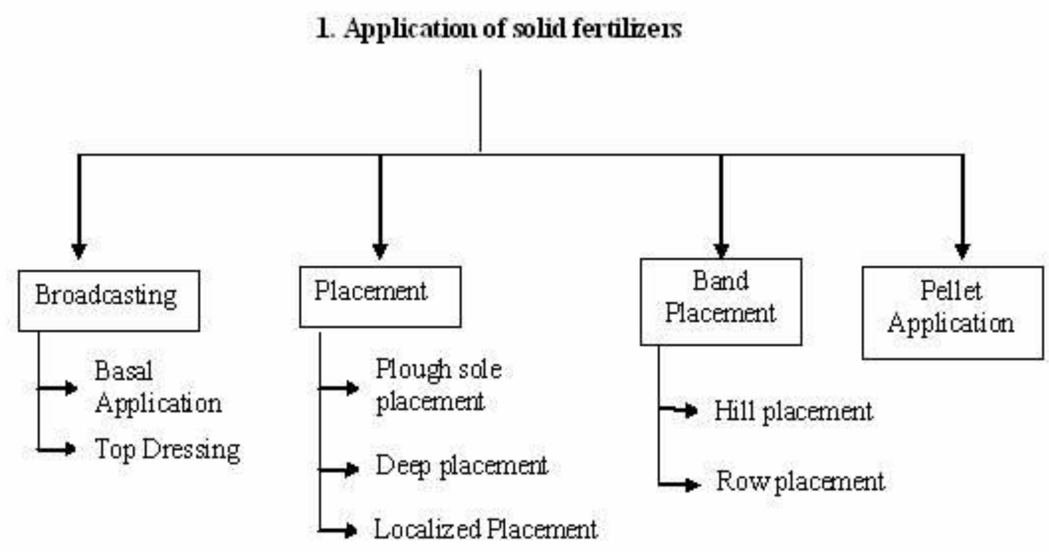
The free-living N-fixer, *Azotobacter* imparts positive benefits to the crops through small increase in N input from BNF, development and branching of roots, production of plant growth hormones, enhancement in uptake of NO_3-, NH_4+, H_2PO_4-, K+ and Fe_2+, improved water status of the plants, increased nitrate-reductase activity and production of antifungal compounds. In irrigated wheat, significant response to *Azotobactor* inoculation was recorded in large number of onfarm trials. *Azotobacter* has been found to contribute, in general, 20- 25 kg N/ha. *Azospirillum* colonises the root mass fixes N in loose association with plants. It has shown positive interaction with applied N in several field crops with an average response equivalent to 15-20 kg/ha of applied N. Several strains of P solubilizing bacteria and fungi have been isolated and inoculation with *Psolubilizing* microbial cultures is known to increase the dissolution of sparingly soluble P in the soil. Integrated use of the microbial cultures along with low-grade rock phosphate might add about 30-35 kg P_2O_5/ha. Soil inoculation with *Pseudomonas striata*, besides increasing grain yield of wheat, showed residual effect in succeeding maize on alluvial soil of Delhi. In a 3-year field study on sandy loam alluvial soils of *Modipuram*, however, PSM (*Psolubilizing* microbial culture containing *Aspergillus awamori*) inoculation of wheat seed did increase crop response to P and soil available P content over the noninoculated treatments, but the magnitude of increase in these parameters was generally too small to attain statistical significance. In recent years, K mobilising biofertilisers (KMB) and Zn solubilizing biofertilisers (ZnSB) have been introduced to augment the solubility of K and Zn in soil, respectively. The need of such bacteria to be evaluated extensively. Also, liquid biofertilizers have proved superior to the conventional (solid) carrier based ones. Blue-Green Algae (BGA) is another csimportant source of N to wetland rice. The most frequently mentioned estimates of N fixed by BGA inoculation are in the range of 20-30 kg N ha-1. Extensive field studies have shown that the incorporation of Azolla would allow N applications to be reduced by at least 30-40 kg/ha.

The advantages of INM can be broadly enumerated as:-

i) Restoration and sustenance of soil fertility and crop productivity,
ii) Prevention of secondary and micronutrient deficiencies,
iii) Economizing in fertiliser use and improvement in nutrient useefficiency and
iv) Favourable effect on the physical, chemical and biological health of soils

Methods of fertilizer application

The different methods of fertilizer application are as follows:



a) Broadcasting

1. It refers to spreading fertilizers uniformly all over the field.
2. Suitable for crops with dense stand, the plant roots permeate the whole volume of the soil, large doses of fertilizers are applied and insoluble phosphatic fertilizers such as rock phosphate are used.

Broadcasting of fertilizers is of two types.

i) Broadcasting at sowing or planting (Basal application):- The main objectives of broadcasting the fertilizers at sowing time are to uniformly distribute the fertilizer over the entire field and to mix it with soil.

ii) Top dressing:- It is the broadcasting of fertilizers particularly nitrogenous fertilizers in closely sown crops like paddy and wheat, with the objective of supplying nitrogen in readily available form to growing plants.

Disadvantages of broadcasting

The main disadvantages of application of fertilizers through broadcasting are:
i) Nutrients cannot be fully utilized by plant roots as they move laterally over long distances.
ii) The weed growth is stimulated all over the field.
iii) Nutrients are fixed in the soil as they come in contact with a large mass of soil.

b) Placement

1. It refers to the placement of fertilizers in soil at a specific place with or without reference to the position of the seed.
2. Placement of fertilizers is normally recommended when the quantity of fertilizers to apply is small, development of the root system is poor, soil have a low level of fertility and to apply phosphatic and potassic fertilizer.

The most common methods of placement are as follows:

i) Plough sole placement:- In this method, fertilizer is placed at the bottom of the plough furrow in a continuous band during the process of ploughing. Every band is covered as the next furrow is turned. This method is suitable for areas where soil becomes quite dry upto few cm below the soil surface and soils having a heavy clay pan just below the plough sole layer.

ii) Deep placement:- It is the placement of ammoniacal nitrogenous fertilizers in the reduction zone of soil particularly in paddy fields, where ammoniacal nitrogen remains available to the crop. This method ensures better distribution of fertilizer in the root zone soil and prevents loss of nutrients by run-off.

iii) Localized placement:- It refers to the application of fertilizers into the soil close to the seed or plant in order to supply the nutrients in adequate amounts to the roots of growing plants.

- The common methods to place fertilizers close to the seed or plant are as follows:

a) Drilling:- In this method, the fertilizer is applied at the time of sowing by means of a seed-cum-fertilizer drill. This places fertilizer and the seed in the same row but at different depths. Although this method has been found suitable for the application of phosphatic and potassic fertilizers in cereal crops, but sometimes germination of seeds and young plants may get damaged due to higher concentration of soluble salts.

b) Side dressing:- It refers to the spread of fertilizer in between the rows and around the plants. The common methods of side-dressing are

1. Placement of nitrogenous fertilizers by hand in between the rows of crops like maize, sugarcane, cotton etc., to apply additional doses of nitrogen to the growing crops and
2. Placement of fertilizers around the trees like mango, apple, grapes, papaya etc.

c) Band placement:- If refers to the placement of fertilizer in bands.

Band placement is of two types:-

i) Hill placement:- It is practiced for the application of fertilizers in orchards. In this method, fertilizers are placed close to the plant in bands on one or both sides of the plant. The length and depth of the band varies with the nature of the crop.

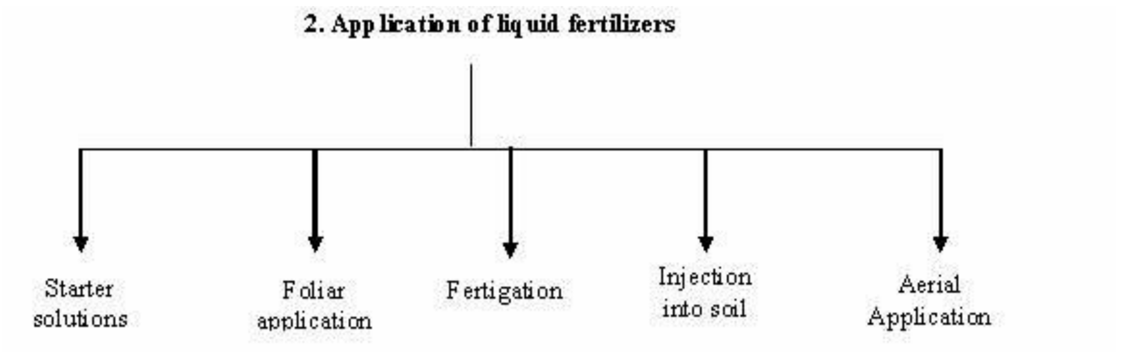
ii) Row placement:- When the crops like sugarcane, potato, maize, cereals etc., are sown close together in rows, the fertilizer is applied in continuous bands on one or both sides of the row, which is known as row placement.

d) Pellet application

1. It refers to the placement of nitrogenous fertilizer in the form of pellets 2.5 to 5 cm deep between the rows of the paddy crop.
2. The fertilizer is mixed with the soil in the ratio of 1:10 and made small pellets of convenient size to deposit in the mud of paddy fields.

Advantages of placement of fertilizers

The main advantages are as follows:
i) When the fertilizer is placed, there is minimum contact between the soil and the fertilizer, and thus fixation of nutrients is greatly reduced.
ii) The weeds all over the field can not make use of the fertilizers.
iii) Residual response of fertilizers is usually higher.
iv) Utilization of fertilizers by the plants is higher.
v) Loss of nitrogen by leaching is reduced.
vi) Being immobile, phosphates are better utilized when placed.



Following are the common methods of applying liquid fertilizers:-

a) Starter solutions:- It refers to the application of solution of N, P_2O_5 and K_2O in the ratio of 1:2:1 and 1:1:2 to young plants at the time of transplanting, particularly for vegetables. Starter solution helps in rapid establishment and quick growth of seedlings.
The disadvantages of starter solutions are:-
(i) Extra labour is required, and
(ii) the fixation of phosphate is higher.

b) Foliar application:- It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants.

- Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them.
- The concentration of the spray solution has to be controlled, otherwise serious damage may result due to scorching of the leaves.
- Foliar application is effective for the application of minor nutrients like iron, copper, boron, zinc and manganese. Sometimes insecticides are also applied along with fertilizers.
- Mostly urea is used for foliar application (2-6%).
- Biuret shouldn't be more than 1.5%.

Application through irrigation water (Fertigation):- It refers to the application of water soluble fertilizers through irrigation water.

- The nutrients are thus carried into the soil in solution.
- Generally nitrogenous fertilizers are applied through irrigation water.

d) Injection into soil

- Liquid fertilizers for injection into the soil may be of either pressure or non-pressure types.
- Non-pressure solutions may be applied either on the surface or in furrows without appreciable loss of plant nutrients under most conditions.
- Anhydrous ammonia must be placed in narrow furrows at a depth of 12-15 cm and covered immediately to prevent loss of ammonia.

e) Aerial application:- In areas where ground application is not practicable, the fertilizer solutions are applied by aircraft particularly in hilly areas, in forest lands, in grass lands or in sugarcane fields etc.

Practice

Multiple Choice Question

1. Best earthworm for vermicomposting in Rajasthan is:-
a. *Eisenia fetida* b. *Pheretima posthuman* c. *Pheretima enlongata* d. All of these
2. Oil cake manure should be mix in soil before sowing:-
a. 10-15 Days b. 30 Days c. 45 Days 10. 60 Days

3. Who discover Indian Indore composting method?
a. L. N. Acharya (1939) b. Sir Albert Howard and Wade (1924-26)
c. Manikam (1967) d. Narayan Rao Pandheri Pandey
4. Fertilizers which are contain two or three primary plant nutrients, known as:-
a. Mixed manure b. Mixed Fertilizer c. Compound Manure d. Compound Fertilzer
5. Completely chlorosis on younger leaves occur due to deficiency of:-
a. Fe,S b. S,Mn c. S,Cu d. Mn,Fe
6. Which one an organic manure:-
a. Urea b. DAP c. SSP d. None of these
7. Nitrate and Nitrite are results of:-
a. Nitrosomonas, Nitrobacter b. Nitrobacter, Nitrosomonas
c. Bacillus, Pseudomonas d. Rhizobium, Bacillus
8. Rock phosphate is best suitable for the……………. soil.)
a. Acidic Soil) b. Neutral Soil c. Alkaline Soil d. Saline Soil
9. Which fertilizer totally manufactured in India:-
a. Muret of Potash b. Sulphate of Potash c. Di Ammonium Phosphate d. a & b
10. What should be concentration of urea in foliar spray?
a. 2% b. 3% c. 4% d. 6%.
11. Which one of them best suitable nitrogenous fertilizer in sub-merged soils:-
a. Ammonium Sulphate b. CAN c. Urea d. All
12. Nitrogenous fertilizers are applied into crops:-
a. After Sowing b. Split doze c. at sowong time d. None of these

Fill in the Blank

1. The name Rhizobium was established by ………….. in 1889.
2. Rhizobium fix …………….kg nitrogen per hector.
3. ………. and Sun hemp are mostly used for green manuring.
4. The Indian Indoor Method of manuring developed by……………..
5. Urea content ………………% N.
6. SSP content …………………% P.
7. MOP Content ………………..% K.
8. Gypsum Content …………% Ca and ………..% S.

Descriptive

1. Write down the difference between Manure and Fertilizer?
2. Describe the process of vermicomposting.
3. Write down the classification of Phosphatic fertilizer.
4. What is green manure.?
5. Describe the method of preparation of FYM.
6. What is the biofertilizer. Type of biofertilizer?
7. Explain the nitrogen cycle.

6. Concept of Soil Moisture Availability, Various Irrigation Method. Concept of Precision and Pressure Irrigation. Drip and Sprinkler Irrigation.

Soil water

Water contained in soil is called soil moisture. The water is held within the soil pores. Soil water is the major component of the soil in relation to plant growth.

Physical Classification of Soil Water:-

1. Hygroscopic water: This water forms very thin films around soil particles and is not available to the plant. The water is held so tightly by the soil that it cannot be taken up by roots. Hygroscopic water held so tenaciously (-31 to -10000 bar/-449.6 psi to -145037.738 psi) by soil particles that plants cannot absorb it.

2. Capillary water: Capillary water is held in the capillary pores (micro pores). Capillary water is retained on the soil particles by surface forces. It is held so strongly that gravity cannot remove it from the soil particles. The molecules of capillary water are free and mobile and are present in a liquid state. Due to this reason, it evaporates easily at ordinary temperature though it is held firmly by the soil particle; plant roots are able to absorb it. Capillary water is, therefore, known as available water. The capillary water is held between -1/3 and -31 bar (-4.8 psi to -449.6 psi).

3. Gravitational water:- Gravitational water occupies the larger soil pores (macro pores) and moves down readily under the force of gravity. Water in excess of the field capacity is termed gravitational water. Gravitational water is of no use to plants because it occupies the larger pores. It reduces aeration in the soil. Thus, its removal from soil is a requisite for optimum plant growth. Soil moisture tension at gravitational state is less than -1/3 bar (less than -4.8 psi).

B. Biological Classification of Soil Water:- There is a definite relationship between moisture retention and its utilization by plants. This classification based on the availability of water to the plant. Soil moisture can be divided into three parts.

i. Available water:- The water which lies between wilting coefficient (-15 bar) and field capacity (-1/3 bar). It is obtained by subtracting wilting coefficient from moisture equivalent.

ii. Unavailable water:- This includes the whole of the hygroscopic water (-10000) plus a part of the capillary water below the wilting point (-15 bar).

iii. Super available or superfluous water:- The water beyond the field capacity stage is said to be super available. It includes gravitational water plus a part of the capillary water removed from larger interstices. This water is unavailable for the use of plants. The presence of super-available water in a soil for any extended period is harmful to plant growth because of the lack of air.

- **Field Capacity :-** The maximum quantity of water which a soil can retain against the force of gravity is known as field capacity. Value of field capacity is -1/3 bar.
- **Wilting point:-** Soil moisture content when the rate of absorption of water by plant roots is too slow to maintain plant turgidity and wilting occurs. The value of wilting point is -15 bar (220 psi). Type of wilting:-
  - i. **Temporary Wilting:-** Wilting from which a plant will recover by reduction of the transpiration rate and without addition of water to the soil. The value of temporary wilting is -15 bar.

ii. **Permanent Wilting Point:-** As moisture is lost from the soil, the point at which the force with which the remaining moisture adheres to soil particles exceeds that exerted by plant roots. Plants are therefore unable to absorb moisture and wilting results. Since this condition arises from the amount of water present in the soil, plants will not recover unless water is added to the soil, i.e. the wilting is permanent.

- **Saturation:-** All soil pores are filled with water. This condition occurs right after a rain. This represents 0 bars.
- **Hygroscopic coefficient:-** The hygroscopic coefficient is the maximum amount of hygroscopic water absorbed by 100 g of dry soil under standard conditions of humidity (50% relative humidity) and temperature (15°C). This tension is equal to a force of -31 bar. Water at this tension is not available to plant but may be available to certain bacteria.

S.No.	Moisture Class	Tension (bar)	pF
1.	Chemically Combined	Very High	-
2.	Water Vapour	Held at saturation point in the soil air	-
3.	Hygroscopic	-31 to -10000	4.5 to 7.00
4.	Hygroscopic Coefficient	-31	4.50
5.	Wilting Point	-15	4.20
6.	Capillary	-1/3 to -31	2.54 to 4.50
7.	Moisture equivalent	-1/3 to 1	2.70 to 3.00
8.	Field Capacity	-1/3	2.54
9.	Sticky Point	-1/3	2.54
10.	Gravitational	-1/3-0	<2.54
11.	Maximum water holding Capacity	Almost Zero	-

Forces on Soil Water

1. **Adhesion:-** The attraction o f soil water to soil particles.
2. **Cohesion:-** The attraction of water molecules to other water molecules.
3. **Capillarity:-** A capilary is a very thin tube in which a liquid can move against the force of gravity. The narrower the tube the higher the liquid rises due to the forces of adhesion and cohesion.

Water movement in Soil:-

1. **Infiltration:-** Infiltration is the process by which water on the ground surface enters the soil. Infiltration rate in soil science is a measure of the rate at which soil is able to absorb rainfall or irrigation. It is measured in inches per hour or millimeters per hour. The rate decreases as the soil becomes saturated.
2. **Percolation:-** Percolation is the downward movement of water through saturated or nearly saturated soil in response to the force of gravity. Percolation occurs when water is under pressure or when the tension is smaller than about ½ atmosphere. Percolation rate is synonymous with infiltration rate with the qualitative provision of saturated or near saturated conditions.
3. **Interflow**:- Interflow is the lateral seepage of water in a relatively pervious soil above a less pervious layer. Such water usually reappears on the surface of the soil at a lower elevation.

4. **Leaching**:- **L**eaching reference to a soluble chemical or mineral) drain away from soil, ash, or similar material by the action of percolating liquid, especially rainwater or irrigation water.
5. **Saturated flow:-** The movement of water through a soil that is temporarily saturated. Most of the loosely held water moves downward, and some moves more slowly laterally.
6. **Unsaturated flow:-** The movement of water through a soil that is unsaturated.

Water Requirement and Irrigation Requirement

Water Requirement of Crop:- Water requirement of crop is the quantity of water regardless of source, needed for normal crop growth and yield in a period of time at a place and may be supplied by precipitation or by irrigation or by both.

Water is needed mainly to meet the demands of evaporation (E), transpiration (T) and metabolic needs of the plants, all together is known as consumptive use (CU). Since water used in the metabolic activities of plant is negligible, being only less than one percent of quantity of water passing through the plant, evaporation (E) and transpiration (T), i.e. ET is directly considered as equal to consumptive use (CU). In addition to ET, water requirement (WR) includes losses during the application of irrigation water to field (percolation, seepage, and run off) and water required for special operation such as land preparation, transplanting, leaching etc.

WR = CU + application losses + water needed for special operations.

Water requirement (WR) is therefore, demand and the supply would consist of contribution from irrigation, effective rainfall and soil profile contribution including that from shallow water tables (S)

$$WR = IR + ER + S$$

Under field conditions, it is difficult to determine evaporation and transpiration separately. They are estimated together as evaportranspiration (ET). IR is the irrigation requirement.

Factors influencing Evapotranspiration (ET):-

ET is influenced by atmospheric, soil, plant and water factors.

A) Atmospheric factors:

1) Precipitation
2) Sunshine
3) Wind velocity
4) Temperature
5) Relative humidity

B) **Soil factors:**

1) Depth of water table
2) Available soil moisture
3) Amount of vegetative cover on soil surface.

C) **Plant factors:**

1) Plant morphology
2) Crop geometry
3) Plant cover
4) Stomatal destiny
5) Root depth

D) **Water factors:**

1) Frequency of irrigation
2) Quality of water ET.

Water requirement of any crop depends on crop factors such as variety, growth stage, and duration of plant, plant population and growing season. Soil factors such as temperature, relative humidity, wind velocity and crop management practices such as tillage, fertilization, weeding, etc. Water requirement of crops vary from area to area and even field to field in a farm depending on the above-mentioned factors.

Estimation of Evapotranspiration (ET):

Climate is the most important decides the rate of ET. Several empirical formulas are available to estimate ET from climate date. FAO expert group of scientists has recommended four methods for adoption of different regions of world.

1) Blaney and Criddle method
2) Radiation method
3) Pan evaporation method
4) Modified penman method

Estimation of ET Involves Three Important Steps:

a) Estimation of PET or evapotranspiration (ET) by any four above methods.
b) Estimation of crop co-efficient (KC) and
c) Making suitable adjustments to local growing conditions.

a) **Reference Evapotranspiration (ETO):** ETO can be defined as the rate of evapotranspiration of an extended surface of an 8 to 15 cm tall, green cover, actively growing completely shading the ground and not short of water.

Selection of a method for estimation of ETO depends on availability of metrological data and amount of accuracy needed. Among four methods for estimation of ETO, modified Blaney-Criddle method is simple, easy to calculate and requires data on sunshine (S.S.) hours, wind velocity (WV), relative humidity (RH) in addition to temperature (T).

Among these methods, modified penman method is more reliable with a possible error of 10% only. The possible errors for other methods are 15, 20 and 25% of pan evaporation, radiation and modified Blaney-Criddle methods respectively.

Modified Blaney method:

$$ETO = C [P (0.46 T + 8)] \text{ mm/day}$$

Where ETO = Reference crop ET in mm/day for the month considered
T = Mean daily temperature in oC over the month considered
P = Mean daily percentage of total annual day time hours of a given month and latitude (from standard table)
C = Adjustment factor depends on minimum R.H., Sunshine hours and day time wind estimates.

Pan evaporation method:

$$ETO = Kp/Epan$$

Where Kp = Crop factor
Epan = mean pan evaporation (Epan pan evaporation)

Modified penman method:

$$ETO = C [W.Rn + (1-w). f (U). (ea – ed)]$$

Where Rn = Net radiation in equivalent evaporation expressed as mm/day
W = temperature of altitude related factor
F (U) = Wind related function
Ea – ed= Vapour pressure deficit (mili bar)
C = the adjustment factor (ratio of U day to U night)
Rn (0.75-Rns)
Ea =Saturated vapour pressure (m.bar)
Ed = Mean actual vapour pressure of the air (m. bar)

Crop Coefficient:

Crop co-efficient is the ratio between evapotranspiration of crop (Etc) and potential evapotranspiration and expressed as T (crop) = Kc X ETo

Irrigation requirement:

Irrigation requirement is the total quantity of water applied to the land surface in supplement to the water supplied through rainfall and soil profile to meet the water needs of crops for optimum growth.

$$IR = WR – (ER + S)$$

Net irrigation requirement:

The net irrigation requirement is the amount of irrigation water just required to bring the soil moisture content in the root zone depth of the crops to field capacity. Thus, net irrigation requirement is the difference between the field capacity and soil moisture content in the root zone before application of irrigation water.

Gross irrigation requirement:

The total amount of water inclusive of water in the field applied through irrigation is termed as gross irrigation requirement, which in other words is net irrigation requirement plus application and other losses.

Methods of irrigation:-Irrigation water can be applied to crop lands using one of the following irrigation methods :

(i)Surface irrigation

(a)Uncontrolled (or wild or free) flooding method,

(b)Border strip method,

(c)Check method,

(d)Basin method,

(e) Ring method and

(f)Furrow method.

(ii)Subsurface irrigation

(iii)Sprinkler irrigation

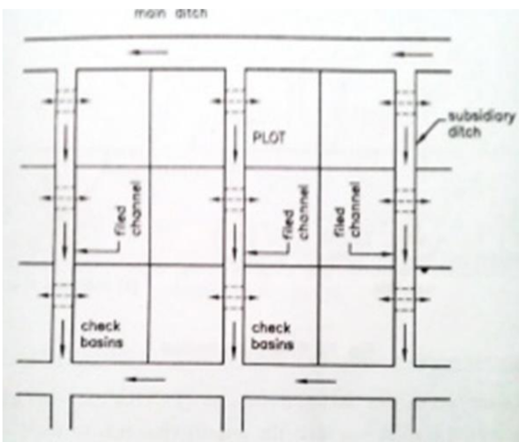
(iv)Trickle (Drip) irrigation

(V) Matka Irrigation Method

Each of the above methods has some advantages and disadvantages, and the choice of the method depends on the following factors:

- Size, shape, and slope of the field,
- Soil characteristics,
- Nature and availability of the water supply subsystem,
- Types of crops being grown,
- Initial development costs and availability of funds, and
- Preferences and past experience of the farmer

(i) **Surface Irrigation:-** In all the surface methods of irrigation, water is either ponded on the soil or alloed to flow continuously over the soil surface for the duration of irrigation. Although surface irrigation is the oldest and most common method of irrigation (90% adopted in worldwide) , it does not result in high levels of performance. This is mainly because of



uncertain infiltration rates which are affected by year-to-year changes in the cropping pattern, cultivation practices, climatic factors, and many other factors. As a result, correct estimation of irrigation efficiency of surface irrigation is difficult. Application efficiencies for surface methods may range from about 40 to 80 per cent.

(a) Uncontrolled Flooding:-When water is applied to the cropland without any preparation of land and without any levees to guide or restrict the flow of water on the field, the method is called 'uncontrolled', wild or 'free' flooding. In this method of flooding, water is brought to field ditches and then admitted at one end of the field thus letting it flood the entire field without any control. Uncontrolled flooding generally results in excess irrigation at the inlet region of the field and insufficient irrigation at the outlet end. Application efficiency is reduced because of either deep percolation (in case of longer duration of flooding) or flowing away of water (in case of shorter flooding duration) from the field. The application efficiency would also depend on the depth of flooding, the rate of intake of water into the soil, the size of the stream, and topography of the field.

Obviously, this method is suitable when water is available in large quantities, the land surface is irregular, and the crop being grown is unaffected because of excess water.

- The advantage of this method is the low initial cost of land preparation.
- This method is the cheapest method.
- This method is sutable fore paddy, jute, bursum.
- There is a lot of water loss in this method.
- This method is inappropriate in undulated land.
- In this method water does not spread uniformly

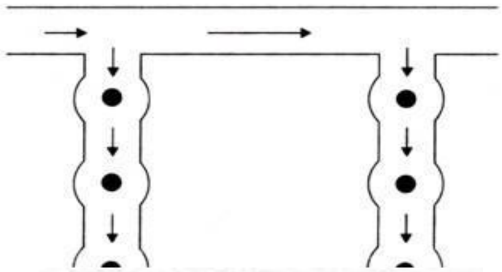
(b) Border Strip Method:-Border strip irrigation (or simply 'border irrigation') is a controlled surface flooding method of applying irrigation water. In this method, the farm is divided into a number of strips. These strips are separated by low levees (or borders

Water from the supply ditch is diverted to these strips along which it flows slowly towards the downstream end and in the process it wets and irrigates the soil. When the water supply is stopped, it recedes from the upstream end to the downsteam end. The border strip method is suited to soils of moderately low to moderately high intake rates and low erodibility. This method, however, requires preparation of land involving high initial cost

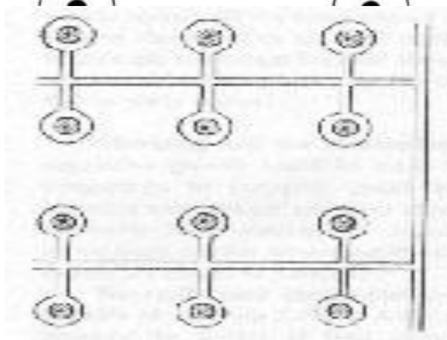
c) Check Basin Method:-The check Basin method of irrigation is based on rapid application of irrigation water to a level or nearly level area completely enclosed by dikes. In this method, the entire field is divided into a number of almost levelled plots (compartments or 'Kiaries') surrounded by levees. Water is admitted from the farmer's watercourse to these plots turn by turn.

- This method is suitable for a wide range of soils ranging from very permeable to heavy soils.
- The farmer has very good control over the distribution of water in different areas of his farm.
- Loss of water through deep percolation (near the supply ditch) and surface runoff can be minimised and adequate irrigation of the entire farm can be achieved.
- Thus, application efficiency is higher for this method.
- However, this method requires constant attendance and work (allowing and closing the supplies to the levelled plots).
- Besides, there is some loss of cultivable area which is occupied by the levees.

- Sometimes, levees are made sufficiently wide so that some ‘row’ crops can be grown over the levee surface.
- It is most popular method in India.
- This method is mostly adopted in wheat, barley, chick pea and vegetables.



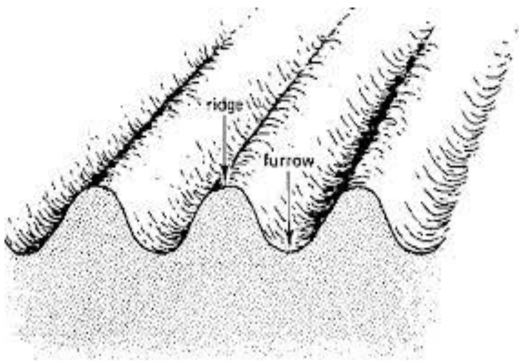
(d) Basin Method:- This method is frequently used to irrigate orchards. Generally, one basin is made for one tree. However, where conditions are favourable, two or more trees can be included in one basin. In this method there is a possibility of infections of diseases.



(e) Ring Method:- This is the most suitable method of irrigation for fruit trees. In this method diseases are not transmitted one plant to another. In this method no chance of damping off.

(e) Furrow Method:- In the surface irrigation methods, the entire land surface is flooded during each irrigation. An alternative to flooding the entire land surface is to construct small channels along the primary direction of the movement of water and letting the water flow through these channels which are termed ‘furrows’, ‘creases’ or ‘corrugation’. Furrows are small channels having a continuous and almost uniform slope in the direction of irrigation. Water infiltrates through the wetted perimeter of the furrows and moves vertically and then laterally to saturate the soil. Furrows are used to irrigate crops planted in rows.

Furrows necessitate the wetting of only about half to one-fifth of the field surface. This reduces the evaporation loss considerably. Furrows provide better on-farm water management capabilities for most of the surface irrigation conditions, and variable and severe topographical conditions. For example, with the change in supply conditions, number of simultaneously supplied furrows can be easily changed. In this manner, very high irrigation efficiency can be achieved.



The following are the disadvantages of furrow irrigation:-

- Loss of water at the downstream end unless end dikes are used,
- The necessity of furrow construction,
- Possibility of increased erosion, and
- Furrow irrigation requires more labour than any other surface irrigation method.

Subsurface Irrigation:- Subsurface irrigation (or simply sub irrigation) is the practice of applying water to soils directly under the surface. Moisture reaches the plant roots through capillary action. The conditions which favor sub irrigation are as follows:-

(i)Impervious subsoil at a depth of 2 meters or more, (ii)A very permeable subsoil,

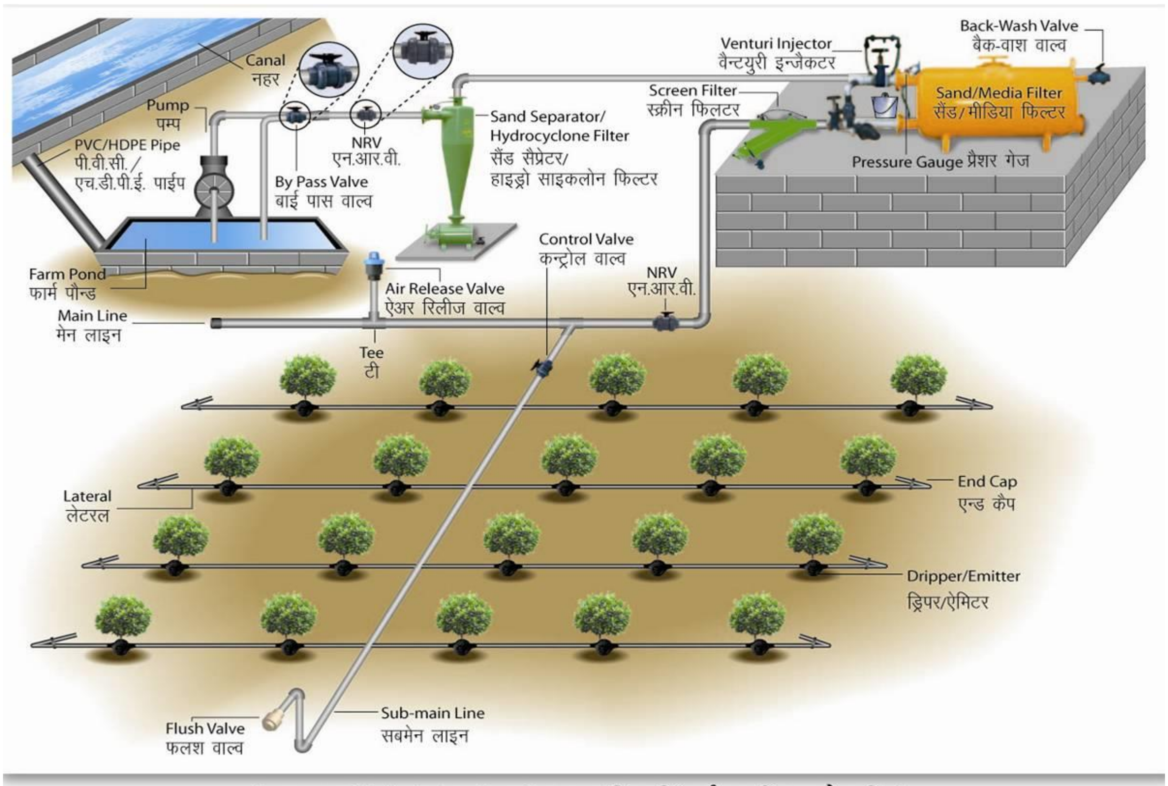
(iii)A permeable loam or sandy loam surface soil,

(iv)Uniform topographic conditions, and

(v)Moderate ground slopes.

In natural sub irrigation, water is distributed in a series of ditches about 0.6 to 0.9 meter deep and 0.3 meter wide having vertical sides. These ditches are spaced 45 to 90 meters apart. Sometimes, when soil conditions are favorable for the production of cash crops (i.e., high-priced crops) on small areas, a pipe distribution system is placed in the soil well below the surface. This method of applying water is known as artificial sub-irrigation. Soils which permit free lateral movement of water, rapid capillary movement in the root-zone soil, and very slow downward movement of water in the subsoil are very suitable for artificial sub-irrigation. The cost of such methods is very high. However, the water consumption is as low as one-third of the surface irrigation methods. The yield also improves.

Sprinkler Irrigation:- Sprinkling is the method of applying water to the soil surface in the form of a spray which is somewhat similar to rain. In this method, water is sprayed into the air and allowed to fall on the soil surface in a uniform pattern at a rate less than the infiltration rate of the soil. This method started in the beginning of this century and was initially limited to nurseries and orchards. In the beginning, it was used in humid regions as a supplemental method of irrigation. This method is popular in the developed countries and is gaining popularity in the developing countries too.



Layout of Drip Irrigation System (ड्रिप सिंचाई पद्धति का रेखाचित्र)

Rotating sprinkler-head systems are commonly used for sprinkler irrigation. Each rotating sprinkler head applies water to a given area, size of which is governed by the nozzle size and the water pressure. Alternatively, perforated pipe can be used to deliver water through very small holes which are drilled at close intervals along a segment of the circumference of a pipe. The trajectories of these jets provide fairly uniform application of water over a strip of cropland along both sides of the pipe. With the availability of flexible PVC pipes, the sprinkler systems can be made portable too.

Sprinklers have been used on all types of soils on lands of different topography and slopes, and for many crops.

The following conditions are favourable for sprinkler irrigation:-

- Very previous soils which do not permit good distribution of water by surface methods,
- Lands which have steep slopes and easily erodible soils,
- Irrigation channels which are too small to distribute water efficiently by surface irrigation, and
- Lands with shallow soils and undulating lands which prevent proper leveling required for surface methods of irrigation.

Advantages:-

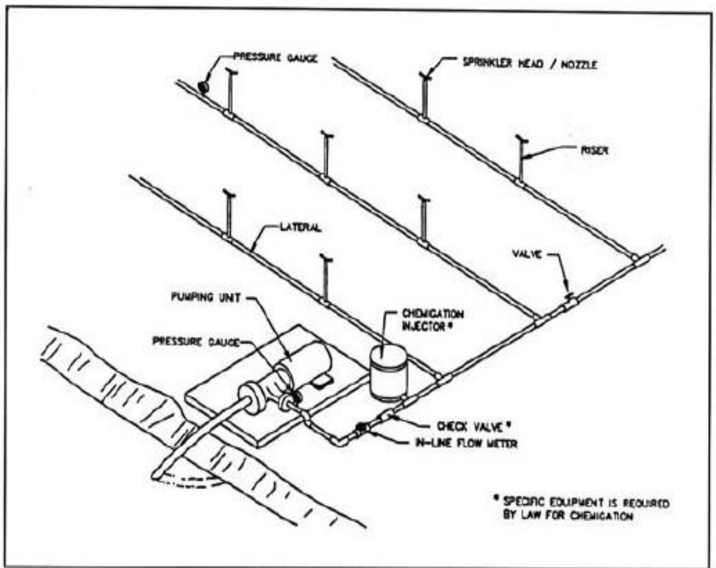
- In the method, approximately 80 percent of the water is consumed by plants, whereas in conventional method only 30 percent of the water is used.
- In this method save 30-50% water.
- In this method the pressure is kept 2-2.5kg / cm^2.
- Saving in fertilizer
- Suitable for any topography
- No soil erosion
- Better seed germination, free aeration of root zone.
- Uniform application of water.

Disadvantages:-

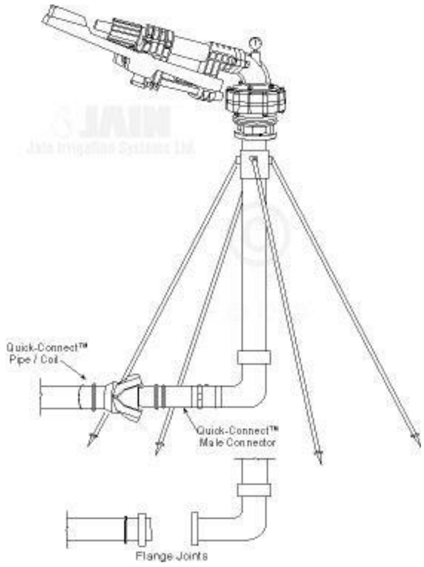
- High initial cost, cannot adopt by ordinary farmers
- Poor application efficiency in windy weather and high temperature
- High evaporation losses
- Water should be free of debris
- Equipments need careful handling
- Physical damage to crops by application of high intensity spray
- Power requires for running pumping unit.
- It is not suitable for tree.

Trickle (Drip) Irrigation:-

Trickle irrigation (also known as drip irrigation) system comprises main line, sub mains, laterals, valves (to control the flow), drippers or emitters (to supply water to the plants), pressure gauges, water meters, filters (to



remove all debris, sand and clay to reduce clogging of the emitters), pumps, fertilizer tanks, vacuum breakers, and pressure regulators. The drippers are designed to supply water at the desired rate (1 to 10 liters per hour) directly to the soil. Low pressure heads at the emitters are considered adequate as the soil capillary forces causes the emitted water to spread laterally and vertically. Flow is controlled manually or set to automatically either deliver desired amount of water for a predetermined time, or supply water whenever soil moisture decreases to a predetermined amount.



Advantages:-

- Low water loss and hence saves water
- Enhances plant growth and plant yield
- Saves labor and energy
- Control weed growth
- No soil erosion
- Improves fertilizer application efficiency.
- With this method water saving is 50-70%.
- By this method, fertilizer savings are 30-60%.
- Production increases by 20-40%.
- The most useful method for saline and alkaline soil is.
- In this method, the water from which water is drip is called a dripper or a meter.
- Rajasthan remains the most problem in this method.
- In this method the pressure is kept 2.5kg / cm2.

Disadvantages:-

- High skill in design, installation, and subsequent operation
- Clogging of small conduits and openings in emitters due to sand, clay particles, debris, chemical precipitates and organic growth
- Not suitable for closely planted crops such as wheat and other cereal grains.

Rain gun Irrigation Method:- Rainguns are available with operating pressure of 2.0 to 7.5 kg/cm2 and flows of 3 to 30lps usually with nozzle diameters ranging from 10 to 30 mm and with a wetting radius of 27 to 60 metre.

Matka Irrigation Method: - The conditions of the clocks in the farm should be determined. This distance is kept low for more and direct stagnant crops for the crops that are cultivated. In order to place the pitcher, it should be kept separately by digging the pits of 60 cm deep and 90 centimeters in diameter. Mix the dirt of the soil (less than one centimeter) and add the basic amount of fertilizer and fertilizers (phosphorus and potash) in it. If necessary, land treatment medication should also be provided. Mix the nitrogen with soil in the first 30 centimeter layer in the pits for irrigation through the clay. After this, placing the pitcher in the pits and clogging the clay around the pitcher. Through which the plow will go completely inside the ground. A heavy layer of sand is kept around the pitcher in a heavy soil farm. In the absence of good contact, the water will either not get out of the pitcher or the drift will be irregular. The pitcher should be filled with clean water. To fill the pitcher, apply two to three days after 6 to 8 plants or seeds around the pitcher. These plants or seeds must be around four distances similar to the pitcher. In fact, plants will develop from water and moisture emanating from the pitcher.

Water Requirement

Crops	**Water requirement (mm)**
Rice	900-2500
Wheat	450-650
Sorghum	450-650
Maize	500-800
Sugarcane	1500-2500
Groundnut	500-700
Cotton	700-1300
Soybean	450-700
Tobacco	400-600
Tomato	600-800
Potato	500-700
Onion	350-550
Chilli	500
Sunflower	350-500
Castor	500
Dolichus been	300-500
Cabbage	380-500
Pea	350-500
Banana	1200-2200
Citrus	900-1200
Pineapple	700-1000
Ray	400-450
Grapes	500-1200

Critical Stage for Irrigation of different crops

Crops	Critical Stages
Rice	Initial tillering, flowering
Wheat	Most critical stage: Crown root initiation, tillering, jointing,. booting, flowering, milk and dough stages
Pulses	Flowering and podding.
Peas	Pre bloom stage.
Berseem	After each cutting.
Gram	Pre flowering and flowering.
Pigeonpea	Flower initiation, pod filling.
Sorghum	Initial seedling, pre flowering, flowering, grain formation.
Barley	Boot stage, dough stage
Maize	Early vegetative, taselling and silking stage.
Groundnut	Flowering, Pegging, and Pod filling
Sesames	Flowering and Ripening
Sun flower	Before flowering and after flowering
Soybean	Flowering stage, Dough Stage
Mustered	Before Flowering, pod filling
Linseed	Before Flowering, pod filling
Sugarcane	Germination, Tailoring Stage, growth stage
Cotton	Sympodial branching and square formation stage, Flowering and fruiting stage, Peak boll formation, Boll development and boll opening stage
Tobacco	Immediately after transplanting and knee stage.
Citrus	Fruit setting and enlargement stage.
Banana	Early vegetative period, flowering and yield formation.
Tomato	From the commencement of fruit set.
Potato	Tuber initiation to tuber maturity.
Cabbage	Head formation until become firm.
Carrot	Root enlargement.

Practice

Multiple Choice Question

1. CRI is related to:-
a. Wheat b. Rice c. Maize d. Sugarcane
2. Field capacity is:-
a. -31 atm b. -15 atm c. -1/3 atm d. 0 atm
3. Maximum water requirement crop is:-
a. Wheat b. Rice c. Maize d. Sugarcane
4. Which one is available water for plant?
a. Capillary water b. Hygroscopic water c. Gravitational Water d. All of theses
5. Water requirement of wheat is?
a. 400-500mm b. 450-650mm c. 600-800mm d. 1200 mm

Fill in the blank

1. ……………… is the process by which water on the ground surface enters the soil.
2. WR = ……………. + application losses + water needed for special operations.
3. In drip irrigation pressure is kept …………………kg / cm2.
4. All soil pores are filled with water is known as…………………
5. Taselling and silking stage of irrigation is………………..

Descriptive

1. Describe the Drip Irrigation?
2. Write down the biological classification of soil water?
3. Write down the advantage and disadvantage of sprinkler irrigation?
4. Write down the critical irrigation stage of Wheat, Maize, Sugarcane and Groundnut.
5. Write a summery on rain gun.

7. Method of Insect-Pest Management Chemical, Biological and Mechanical. Concept of Integrated Pest Management.

Insect-Pest Management

Introduction

Insects are found in all types of environment and they occupy little more than two thirds of the known species of animals in the world. Insects affect human beings in a number of ways. Many of them fed on all kinds of plants including crop plants, forest trees, medicinal plants and weeds. They also infest the food and other stored products in godowns, bins, storage structures and packages causing huge amount of loss to the stored food and also deterioration of food quality. Insects inflict injury to plants and stored products either directly or indirectly in their attempts to secure food. Insects that cause less than 5 % damage are not considered as pests. The insects which cause damage between 5 - 10% are called minor pests and those that cause damage above 10% are considered as major pests. Insects that cause injury to plants and stored products are grouped into two major groups namely chewing insects and sucking insects. The former group chews off plant parts and swallow them thereby causing damage to the crops. Sucking insects pierce through the epidermis and suck the sap. Many of the sucking insects serve as vectors of plant diseases and also inject their salivary secretions containing toxins that cause severe damage to the crop.

Introduction of high yielding varieties, expansion in irrigation facilities and indiscriminate use of increased rates of agrochemicals such as fertilizers and pesticides in recent years with a view to increase productivity has resulted in heavy crop losses due to insect pests in certain crops. This situation has risen mainly due to elimination of natural enemies, resurgence of pests, and development of insecticide resistance and out-break of secondary pests.

Insect-Pest Control Method

A. Cultural Control

Surprisingly simple modifications of a pest's environment or habitat often prove to be effective methods of pest control. As a group, these tactics are usually known as cultural control practices because they frequently involve variations of standard horticultural, silvicultural, or animal husbandry practices. Since these control tactics usually modify the relationships between a pest population and its natural environment, they are also known, less commonly, as ecological control methods. Simplicity and low cost are the primary advantages of cultural control tactics, and disadvantages are few as long as these tactics are compatible with a farmer's other management objectives (high yields, mechanization, etc.). Unfortunately, there are still a wide variety of insect pests that cannot be suppressed by cultural methods alone. There are following practice done for cultural control:-

1. Crop Rotation:- Certain pests are more common in some crops than in others. Rotating crops to different sites can isolate pests form their food source or can change the conditions pests must tolerate. If another site is not available, change the type of crops grown in the garden plot. Do not put members of the same plant family in the same location in consecutive seasons. For example, do not follow melons with cucumbers or squash. This is also true for rotations using green manure crops, which add organic matter to the soil when they are tiled in before they produce flowers or seeds. Waiting two years to plant the same family of vegetable in the same location is the most effective rotation practice; however, yearly rotations can also be beneficial. Rotating annual flower plantings is also a good practice.

2. Sanitation:- Sanitation is another cultural control strategy that may be highly effective for some pests. Removing crop debris from cotton fields after harvest eliminates overwintering populations of pink bollworms (*Pectinophora gossypiella*), European corn borers (*Ostrinia nubilalis*), and sugarcane borers (*Diatraea saccharalis*). Collecting dropped fruit from beneath an apple tree reduces the next season's population of apple maggots (*Rhagoletis pomonella*), codling moths (*Cydia pomonella*), and plum curculio (*Conotrachelus nenuphar*). Shredding or burning the pruning wood from a peach orchard kills shothole borers (*Scolytus rugulosus*) and lesser peach tree borers (*Synanthedon pictipes*) that would otherwise emerge and rein fest the orchard. Clean cultivation is often recommended as a way to eliminate shelter and/or overwintering sites for pest populations. Simply tilling or ploughing a corn field before winter may disrupt a pest's life cycle by causing mechanical injury, by increasing exposure to lethal cold temperatures, by intensifying predation by birds or small mammals, or by burying the pests deep beneath the soil surface. Populations of corn earworms and European corn borers have been greatly reduced in recent years by community-wide efforts to plough under corn stubble after harvest.

3. Soil Solarization:- A clear plastic sheet spread over the soil traps solar heat, which kills soil borne diseases, insects, nematodes, and many weed seeds. The treatment should occur during summer’s high air temperatures and intense solar radiation. Keep the soil damp during the solarization process, and keep the plastic in place for several weeks.

4. Timed Plantings and Harvests:- Many crops may be planted or harvested early to miss heavy pest infestations, while still achieving a full yield. Planting earlier than normal may involve the use of cold frames or hot caps to protect seedlings form the weather while they get a head start growing. The crop then has a competitive edge over pests. Early planting depends upon the gardener knowing the emergence times and life cycles of the pests to be controlled.

5. Resistant Varieties:- When buying seeds or plants, try to choose those with built-in resistance to diseases and nematodes.

6. Intercropping:- Intercropping (also known as mixed cropping) is another way to reduce pest populations by increasing environmental diversity. In some cases, intercropping lowers the overall attractiveness of the environment, as when host and non-host plants are mixed together in a single planting. But in other cases, intercropping may concentrate the pest in a smaller, more manageable area so it can be controlled by some other tactic. Strips of alfalfa, for example, are sometimes interplanted with cotton as a trap crop for lygus bugs (Miridae). The alfalfa, which attracts lygus bugs more strongly than cotton, is usually treated with an insecticide to kill the bugs before they move into adjacent fields of cotton.

7. Certified Plants:- When they are available, consider buying plants labelled as “certified” or grown and inspected under sterile or quarantined conditions. Certified plants may cost more than others, but the certification guarantees they are free of diseases. Strawberries and potatoes are among crops which may be offered as certified plants.

8. Allelopathy:- Allelopathy, a natural chemical interaction among plants, has been the subject of much research recently. Allelopathy refers to stimulatory as well as inhibitory properties. A living plant may release toxins, or in the case of decaying plant tissues, microorganisms may play a role in the release of the toxin. The microbes may also modify nontoxic compounds into toxic compounds. Black walnut trees and Johnson grass are among plants that have been shown to inhibit the growth of winter annual weeds and may offer some control of root knot nematode.

B. Mechanical Control

Destruction of the pest by mechanical means such as burning, trapping, protective screens and barriers or use of temperature and humidity is often useful.

1. Handpicking:- When the infestation is low, the pest is conspicuous and labor is cheap, the pest stages can be destroyed by mechanical means. Eggs of grasshoppers can be destroyed by hand. Alfalfa aphids can be killed by using chain drags on plants less than 10 inches long. Locust nymphs which are congregating can be beaten by sticks and brooms. European corn borer in the stalk can be killed by running the corn stalks through the stalk shredder. Handpicking of sugarcane borer eggs, cabbage butterfly eggs, sawfly larvae on mustard, *Papilio* larvae from citrus plants and stages of *Epilachna*beetle is very effective, especially in small areas.

2. Burning:- Controlled burning is sometimes recommended to control certain pests. Weedy fallows harboring European corn borers are burnt to destroy overwintering pest stages. To eradicate the pink bollworm dried cotton stalks are piled and dried. Trash and garbage, weeds etc. are collected and burnt to destroy pest stages. Flamethrowers are used to burn locust hoppers and adults that are congregating and marching.

3. Trapping:- Trapping is popular method to lure insects to bait, light etc. to kill them. Traps usually fail to give adequate crop protection but prove useful to know population build up and are convenient to collect insect samples. Many trap designs have been developed room time to time to suit different insect species. Hopper-dozers were formerly used to collect grasshoppers. In these the insects after hitting the back of the machine fall to the bottom and then through a narrow opening collect into a box. Yellow-pan traps containing water and few drops of oil were proved useful in killing hopper adults on paddy, sugarcane and wheat crops. Sticky traps are boards of yellow color smeared with sticky substance, which trap and kill the flying insects that are attracted to and try to rest on it. Pitfall traps are pan-like containers bearing insecticide and embedded below the ground level. Crawling and fast-running insects often fall into them and die. Light traps attract night-flying insects, which fall into a container having insecticide, water or oil, or hit an electric grid. Light source emitting UV light is most attractive to insects. Pheromoe traps are particularly effective against the lepidopterous pests. Females release specific pheromone to which males are attracted from considerable distance.

4. Barriers:- In certain instances, barriers may prevent insects from infesting the crop. Cloth screens over seedbeds protect the younger plants from insects, like flea beetles, hoppers, armyworms etc. Metal collars around young plants protect them from cutworms. Trench barriers are used to stop chinch bugs, armyworms, locusts etc. Metal or concrete barriers are used against termites. Barrier spraying of residual insecticides has become more popular against termites, locusts and several other insects. Sticky bands applied around mango tree-trunks during December-January prevent the upward movement of mango mealy bugs, which upon hatching begin to crawl up the trunk to reach the leaves.

5. Temperature control:- Temperature extremes are fatal to insects. This method is used against stored grain pests. Low temperatures that are enough to dormancy can prevent damage. Low temperatures are utilized for the control of insects in flourmills and warehouses. Exposure to subzero temperature for 24 hours is lethal to most of the insects.

6. Drying:- Insects infesting stored grains require certain amount of moisture to develop. Neither the rice weevils nor the granary weevils can survive moisture contents as low as 8.0%. Drying the grains either in the sun or by heat blowers reduces infestation of majority of stored grain insects.

7. Radiation:- Gamma radiation kills all stages of the pests in storage conditions. This is a common method employed to kill insect stages during export or imports of huge quantities of grains, fruits and vegetables.

8. Ultrasonic vibrations:- Moths are often sensitive to bats' ultrasonic signals and quickly escape from the area. Imitation of the bat's echolocation system helps in scaring away the lepidopterous insect pests from the area.

C. **Biological Control**

Regulation of pest abundance below the level of economic injury is the target of biological control, which is usually done by study, importation, augmentation and conservation of beneficial organisms for the regulation of harmful animal's population. Most of the agricultural pests are insects and these have natural enemies, which are also mostly insects. Therefore most of the examples of biological control come from insects.

Definition:- Biological control is the action of natural enemies (parasites, predators and pathogens) in maintaining another organism's population density at a lower level than would occur in their absence.

The importance of biological control has lately been enhanced due to the fact that overwhelming use of insecticides has led to the resurgence of the pests and resistance to insecticides by the pests like mosquitoes, houseflies and stored grain pests. Biological control is based on the utilization of ecological principles; hence it is frequently called Applied Ecology. Maintenance of the balance of nature is an important aspect of biological control.

Natural Biological Control:- includes role of natural enemies to contain pest populations in an undisturbed environment.

Applied Biological Control:- includes manipulation of biotic factors (natural enemies) by man to reduce the population of a pest species.

Pests of foreign origin usually do not cause serious damage in their native country because there they are kept under check by natural enemies. But when accidentally introduced into a new country they multiply unchecked and become serious pests. Role of biological control is to find out natural enemies of such pests and introduce them in the areas of pest outbreak. Against pests of domestic origin also exotic natural enemies of species closely related to the indigenous pest are imported and released.

Examples: Control of cottony cushion scale (*Icerya purchasi*) by using vedalia beetle (*Rodolia cardinalis*) in California in 1988 is an outstanding success story. In 1887, citrus industry in California suffered massive destruction by the cottony cushion scale. Chemical control had failed.

A German scholar, Albert Koebele, was assigned the job to find out natural enemies of this pest in its native home, Australia and New Zealand. In Australia, Koebele found a ladybird beetle, *Rodolia cardinalis* and a dipteran fly, Chryptochaetum feeding on the pest stages. He dispatched many consignments of the two species to USA for release in the orchards. Chryptochaetum failed to establish but Rodolia multiplied so fast that by July, 1889 the scale was virtually wiped out from the valley.

Another outstanding example is the control of cactus, *Opuntia stricta* by the Argentine moth, *Cactoblastis cactorum* in Australian grasslands in 1927-30.

Bacillus thuringiensis is a pathogen which is widely used to control caterpillars of many pest species commercially.

Many outstanding works on biological control have been done in Australia, Canada, Chile, Fiji, Hawaii, Japan, New Zealand, and India. Successes have been reported in over 60 countries. Commonwealth Institute of Biological Control, with headquarters in London and Indian station at Bangalore, is noteworthy for its contribution.

Some terms and definitions

Parasite:- An organism that derives its nutritional requirements from another organism, killing it slowly or not killing it at all.

Predator:- When one organism kills another instantly for food.

Ectoparasite:- Parasites which feed on the host from outside their bodies. Examples are larvae of parasitic Hymenoptera and Diptera.

Endoparasite:- Parasites which live inside the body of the host and derive their nutrition from it.

Parasitoid:- Larvae of Diptera and Hymenoptera which live as parasites in early stages but behave like predators when nearing maturity and kill the host before emergence.

Protelian parasites:- Insects in which only the immature stage is parasitic and not the adult. Examples are parasitic Hymenoptera and Diptera.

Superparasitism:- When a parasite oviposits in a host, which is already parasitized by the parasite of the same species.

Hyperparasitism:- When a parasite develops on another parasite, which is on the host. The parasite that attacks the host is called primary parasite and the one that attacks the primary parasite is calledsecondary parasite.

Multiple parasitism:- When two or more species of parasites oviposit in the same host. Normally only one parasite manages to develop to maturity.

Applied biological control is practiced in the following three ways:

1) Importation and colonization of exotic natural enemies:- When the target pest is of foreign origin, it is always advantageous to search for its natural enemies in the country of its origin. It is taken as a general rule that the predominant natural enemy occurring at relatively low host densities in the native home offers greatest promise for introduction to new environment. Usually the dormant stage of the parasite (eggs or pupae), or the dormant stages of the parasitized host are shipped. Releases should be timed with the availability of the host stages to be parasitized. To evaluate the effectiveness of the natural enemy introduced, samples are collected at regular intervals and analyzed as life-table data.

2) Conservation and inundative releases of indigenous natural enemies:- Conservation of natural enemies demands judicious and minimal use of insecticides on crops, so that parasites and predators are not unnecessarily killed. Selective insecticides which are not harmful to the natural enemies are used, such as organophosphates and methyl esters. Use of favorable application technique, e.g. soil application of systemic insecticides, seed treatment and use of baits, helps to conserve the natural enemies. Sometimes natural enemies are collected from the field, mass-bred in labs and then released in the field, much like biological insecticides, e.g. use of Trichogramma and Bacillus thuringiensis.

3) Manipulation of natural enemies:- When a parasite or predator fails to become effective, ecological, biological and physiological studies are conducted to find out reasons for failure. There are various possible ways of enhancing the effectiveness of natural enemies as follows:

- Development of resistant strains of parasites by artificial selection under controlled conditions.
- Provision for supplementary food for adults.
- Use of behavior modifying chemicals (semiochemicals) is sometimes helpful. Extracts of tomato sprayed on corn increases parasitization of *Heiothis zea*. The predator Chrysopa is strongly attracted to honey dew of aphids. Synomones are chemicals produced by plants which attract natural enemies and Kairomones are chemicals released by host insects that attract natural enemies.
- Genetic improvement of natural enemies by hybridization and artificial selection of different strains, which increases vigour and effectiveness of

parasites and sometimes even resistance to insecticides. Intercropping is known to augment parasitic activity.

Advantages and disadvantages of biological control

Advantages:- It is a long-time self-perpetuating control of the target pest. Unlike insecticides, there is no fear of pest developing resistance. There is no fear of environmental pollution. In this method balance of nature in the ecosystem is not disturbed. This is a long-term control method and cost of controlling the pest is economical. There is no fear of pest resurgence, as normally happens by the application of insecticides.

Disadvantages:- Biological control is a long-term process and takes years before natural enemies could be established and during this period the pest can cause immense damage. Often natural enemies fail to establish, leading to failure of the entire programme. In case of pest outbreak, biocontrol fails to provide immediate relief. In some cases a natural enemy also damages some useful animals or plants. Biocontrol doesn't provide surety. The projects usually have equal chances of failure or success.

Some Indian examples of biological control

1. Biological control of cottony cushion scale in southern India by the introduction and release of *Rodolia cardinalis* from USA in 1928.
2. Control of woolly apple aphid, *Eriosoma lanigerum*, by *Aphelinus mali* introduced from USA in 1941.
3. Partial control of San Jose scale by the introduction and release of *Prospaltella perniciosi* and *Aphytis diaspiditis* from USA in 1961.
4. Control of sugarcane stem borers in some states of India by inundative releases of *Trichogramma minutum, T. japonicum* and *T. australicum*.
5. Control of Lantana weed by the anthocorid bug, *Teleonemia scrupulosa* along the foothills of Himalaya.
6. Biological control of mosquito larvae by the fish *Gambusia* and *Nothobranchius guntheri*.
7. Partial control of *Opuntia spp*. by the cochineal insect, *Dactylopius tomentosus* introduced from South America in 1900.

D. Chemical control of pests

It is the pest control using the chemical pesticides. A pesticide is a chemical used to prevent, destroy, or repel pests. They combat pests and deseases occuring on our crops, livestock and our possessions.

Classifications of pesticides

1. **Sphere of activity:-** They are classifies according to the usefulness
- **Acaricides-** used to control ticks and mites Eg:carbophenothion
- **Insecticides-**Used to control insects Eg:Carbofuron
- **Fungicides-** used to control fungal diseases in plants Eg:Menab
- **Herbicides-** Used to control weeds Eg: MCPA
- **Nematicides-** Chemicals used to control nematodes Eg:Phenamiphos
- **Rodenticides-** Chemicals used to control rats Eg:Coumarin
2. **Mode of action Contact poison:-**
   - **Systematic Pesticide:-** Systemic pesticides are chemicals that are actually absorbed by a plant when applied to seeds, soil, or leaves. The chemicals then circulate through the plant's tissues, killing the insects that feed on them.
   - **Non- Systematic Pesticide:-** Non-systematic pesticide are chemical that are kill any pest when they are contacted with pest.
3. **Chemical constituents:-**
   - **Botanical compounds:-** Eg: Pyrethroids-produced by the ground flowers of daisy *Chysanthemum cinerariaefolum*.
   - **Synthetic organic compounds:-** Organochlorines-insecticides containing C,H, and O. Eg:DDT, Aldrin.
   - **Organophosphorus:-** They are made up of organic molecules containing phosphorus. Carbomates-Structurally esters of unstable carbonic acid.
   - **Microbial compounds:-** Commercially produced insecticides from the natural pathogens of insect .Eg. Bacillus thurengiensis.
   - **Growth regulator compounds:-** Novel compounds which inhibit synthesis in insects. Eg: Atabrai-cabbage caterpillar control, Applaud-brown plant hopper control.
   - **Synthetic pyrethroids:-** They are synthesized from petroleum based chemicals
4. **Types of pesticide formulation:-**
   - Dusts
   - Granules
   - Emulsifiable concentrate (EC)
   - Flowables
   - Wettable powders
   - Poisonous baits

Application of pesticides:- There numerous ways,but knapsack sprayer is the post popular spray equipment.

Advantages and disadvantages of chemical pest control

Advantages

- Cost effectiveness
- Timeliness and flexibility
- Quality, quantity and price of produce
- Prevention of problems
- Protection of the environment

Disadvantages:-

- Reduction of beneficial species. Non-target organisms, including predators and parasites of pests
- Drift of sprays and vapour during application can cause severe damage and residue problems in crops
- Residues in food for humans and feed for livestock
- Ground water contamination by leached chemicals
- Resistance to the pesticide used can develop in target pests due to overuse and incorrect use of the chemical.
- Poisoning hazards and other health effects Poisoning hazards and other health effects

Integrated Pest Management

Integrated Pest Management (IPM) is that method of pest control, which utilizes all suitable techniques of pest control to reduce pest populations and maintain them below economic injury level.

IPM is also defined as a stable system of crop protection, which based on the ecological relations within the crop and the environment, combines several methods of pest control in such a way that the pest is prevented from causing economic injury.

The idea of integrated control emerged independently in California and in Netherlands, where it was first known as harmonic control. The term pest management arose in Canada and Australia. It is also called protective management and was originally coined to define the blending of biological control agents with chemical control because these techniques used independently, either failed to produce satisfactory results or caused environmental problems. Therefore, need arose to consolidate these two methods and also other possible means into a unified programme to manage pest population so that economic injury is avoided.

Components of Integrated Pest Management

Various components and techniques that can be utilized in Integrated Pest Management programmes are as follows:

1. Cultural control: Use of resistant varieties of crops is a promising technique in IPM. Moderately to low level of resistance is best integrated with chemical and biocontrol agents. Crop rotation and sanitation are also used to reduce the pest population to lower levels.

2. Mechanical control: Use of screens or barriers or handpicking in nursery stage of the crops and use of light traps to kill egg-laying adults can bring down the population for the other methods to be effective.

3. Biological control: Natural enemies are commonly utilized in IPM programmes. Emphasis is given to protection and augmentation of indigenous natural enemies and recolonisation of those that have been wiped out due to indiscriminate use of insecticides.

4. Chemical control: Minimal use of insecticides is recommended in IPM. Rule of the thumb is not to use insecticides unless absolutely necessary. Application methods that do not bring insecticides in contact with natural enemies are favoured in IPM programmes

5. Regulatory methods: Plant and animal quarantines by the government and collective eradication and suppression in large areas help in providing long-lasting management. International efforts to suppress noxious pests like locusts have proved fruitful.

In most of the cases, chemical, biological and varietal resistances are combined to manage the population of pest species.

Role of biological control in IPM

Being safe, permanent and economical, biocontrol should be of primary consideration in any IPM programme and should not be taken up only when other methods fail. In IPM biological control need not achieve complete success, since other methods combined also contribute in achieving the goal.

There are three major ways to integrate biological control in IPM programmes:

1. Conservation and augmentation of natural enemies already available,

2. Importation and colonization of exotic natural enemies and

3. Mass culture and release of indigenous as well as exotic natural enemies.

Conservation is done by using selective insecticides to which natural enemies are resistant or use of soil application methods or habitat management like planting of nectar producing flowering plants in the vicinity of the crop. Cultural practices which maintain diversity of crops in the area are usually beneficial for the natural enemies. Intercropping of selected crops is known to augment parasitic activity. Integration of moderately resistant crop varieties with natural enemies is currently a popular component of pest management.

Role of insecticides in IPM

When pest populations reach above tolerable levels, insecticides provide immediate control. But great majority of insecticides are broadly toxic and therefore ecologically disruptive. Great need for IPM is to develop selective or even specific insecticides which will have negligible effect on non-target species. Modification of dosage, times of application, formulations and placement of material can be utilized to increase selectivity of chemicals. Successful use of pesticides of mites illustrates bright future for selectivity. Use of pheromones, hormones, repellents, antifeedants and sterilants are selelective in their action and hence must be encouraged.

An elementary integration is the application of insecticides and pheromone traps to reduce male population of the pest before undertaking control through sterile male technique, since the latter is more successful at lower pest densities. An example is the control of Mediterranean fruit fly *(Ceratitis capitata)* onProcida Island in Italy.

Role of varietal resistance in IPM

Use of resistant varieties is a less utilized concept. A low plant resistance is better since it does not impose too much stress on the pest species to change its behavior and develop biotypes. It also harbors natural enemies at low pest densities. A highly resistant crop, on the other hand, wipes out not only the pest species but also the specific natural enemy fauna from the area.

An interesting integration of resistance, cultural practice and chemical control is the planting of trap crop of a susceptible variety or attractive crop on the borders and main crop in the middle, and then spraying only on the susceptible variety where the pest would naturally congregate.

An integration of resistance and biocontrol was shown in California by planting moderately resistant variety of barley and sorghum which complemented the activity of the parasite *Lysiphlebus testaceipes* in reducing green bug (*Schizaphis graminum)* population. Advantages of varietal resistance in IPM programmes include: its specificity, easy compatibility with other methods, cumulative effect is carried through generations over a long period and non-disturbance of ecosystem.

Examples of Integrated Pest Management

1. Cotton pest control in Peru: Developed by Wille (1951) in Canete Valley which is a self-contained ecosystem surrounded by arid areas. Due to extensive use of organic insecticides and subsequent resistance developed by the cotton pests, the valley was led to the brink of disaster. The following steps were taken to save the crops:

- Prohibition of ratooning.
- Prohibition of synthetic organic insecticides and return to the old calcium and lead arsenates and nicotine sulphates.
- Repopulation of the area with; natural enemies introduced from the surrounding regions.
- Establishment of deadlines for planting, ploughing, irrigation, pruning and harvesting.
- Employment of cultural practices, which led to the establishment of healthy, uniform stands.

As a result of this IPM programme, the pest problem was solved and the whole agro-ecosystem twined into a self-balanced system.

2. Integrated Pest Management in Paddy: FAO developed an intercountry programme for IPM in South andSoutheast Asia by integrating biological, chemical and cultural control methods.

3. Integrated Pest Management in Sugarcane: Chemical control is not successful in sugarcane fields because of technical and mechanical problems of insecticide applications and also insecticide contamination eventually reaching humans. Integration of biological contraol, particularly the egg parasite, *Trichogramma*species and modification of cultural practices has been found to keep the pest densities below economic injury levels.

4. Integrated control of locusts: FAO undertakes constant surveillance throughout the breeding areas and follows the following IPM programme: Eggs are destroyed by ploughing or flooding (mechanical control). Nymphs are controlled either by direct spraying by aircrafts or by barrier spraying, baiting, trenching or burning by flame-throwers. Repellents like neem-oil are sprayed on crop at the time of swarming. Swarms are either sprayed while resting on ground or by aircrafts while migrating. Some biological control is achieved by conserving predators in the breeding grounds.

Practice

Define the below mentions

1. IPM
2. Soil Solarization
3. Systematic Pesticide
4. Pesticide
5. Fungicide
6. Biological control of Insect-Pest
7. Parasitoid
8. Protelian parasites
9. Superparasitism
10. Hyperparasitism

Descriptive

1. Describe the IPM.
2. Write down the advantage and disadvantage of Biological control.
3. Draw the flow chart of IPM.

UNIT II. Organic Farming

Present Status

- Total area under organic certification in India is - 1.49 million ha
- Total Organic production in India - 1.35 Million tones
- The state with largest area under organic certification is - Madhya
- Pradesh> Himachal Pradesh> Rajasthan
- India's First organic state- Sikkim (Declared on Jan 18,2016); Second organic state-Uttarakhand
- The country with largest area under organic farming– Australia (27.15 Mha)
- The country with highest number of organic producers in the world :- India (More than 30 per cent of world's organic producers are in India)
- India's rank in terms of organically cultivated area is - 15th
- National Organic Farming Research Institute (NOFRI) in- Sikkim (February 2016)
- National Centre of Organic Farming, Ghaziabad, UP (2004)
- India's First Organic farming University going to be set up in- Vadodara, Gujarath
- Largest exported organic product in India- Oilseeds (50%)> Processed food products>Cereals & millets> Tea>Pulses>Spices

Organic farming is a method of crop and livestock production that involves much more than choosing not to use pesticides, fertilizers, genetically modified organisms, antibiotics and growth hormones.

Organic production is a holistic system designed to optimize the productivity and fitness of diverse communities within the agro-ecosystem, including soil organisms, plants, livestock and people. The principal goal of organic production is to develop enterprises that are sustainable and harmonious with the environment.

As per the definition of the United States Department of Agriculture (USDA) study team on organic farming "organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection".

FAO suggested that "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs".

Concept of organic farming

Organic farming is very much native to this land. Whosoever tries to write a history of organic farming will have to refer India and China. The farmers of these two countries are farmers of 40 centuries and it is organic farming that sustained them. This concept of organic farming is based on following principles:

- Nature is the best role model for farming, since it does not use any inputs nor demand unreasonable quantities of water.
- The entire system is based on intimate understanding of nature's ways. The system does not believe in mining of the soil of its nutrients and do not degrade it in any way for today's needs.
- The soil in this system is a living entity
- The soil's living population of microbes and other organisms are significant contributors to its fertility on a sustained basis and must be protected and nurtured at all cost.
- The total environment of the soil, from soil structure to soil cover is more important.

Main principles of organic farming

The main principles of organic farming are as follows:

- To work as much as possible within a closed system, and draw upon local resources.
- To maintain the long-term fertility of soils.
- To avoid all forms of pollution that may result from agricultural techniques.
- To produce foodstuffs of high nutritional quality and sufficient quantity.
- To reduce the use of fossil energy in agricultural practice to a minimum.
- To give livestock conditions of life that confirm to their physiological need.
- To make it possible for agricultural producers to earn a living through their work and develop their potentialities as human being.

The main pillars of organic farming are:-

- Organic threshold standards
- Reliable mechanisms regarding certification and regulatory affairs
- Technology packages
- Efficient and feasible market network.

History of Organic Farming:-

Organic farming has been practiced in India for thousands of years. The great Indian civilization thrived on organic farming; India was one of the most prosperous countries in the world until the British invaded and ruled it.

In traditional India, the entire industry of agriculture was practiced using organic techniques, where the fertilizers and pesticides were obtained from plant and animal products. Organic farming was the backbone of the Indian economy and cows were worshiped (as is still done) as sacred animals from God. The cow not only provided milk but also provided bullocks (for farming) and dung (which was used as a fertilizer).

Shift to Chemical Farming in the 1960s

During the 1950s and 1960s, the ever-increasing population of India, along with several natural calamities, led to a severe food scarcity in the country. As a result, the government was forced to import food grains from foreign countries.To increase food security, the government had to drastically increase food production in India.

The Green Revolution (under the leadership of M. S. Swaminathan) became the government's most important program in the 1960s. Several hectares of land were brought under cultivation. Hybrid seeds were introduced.

Natural and organic fertilizers were replaced by chemical fertilizers and locally made pesticides were replaced by chemical pesticides. Large chemical factories such as the Rashtriya Chemical Fertilizers were established.

Before the Green Revolution, it was feared that millions of poor Indians would die of hunger in the mid 1970s. However, within a few years, the Green Revolution had shown its impact. The country, which greatly relied on imports for its food supply, reduced its imports every passing year. In the 1990s, India had surplus food grains and had once again become an exporter of food grains to the rest of the world.

As time went by, extensive dependence on chemical farming has shown its darker side. The land is losing its fertility and is demanding larger quantities of fertilizers to be used every season.

Pests are becoming immune to pesticides, requiring the farmers to use stronger and costlier pesticides that can do more damage to the environment. Due to the increased cost of farming, farmers are falling into the trap of money lenders, who are exploiting them to no end, even forcing some to commit suicide. Both consumers and farmers are now gradually shifting back to organic farming in India.

It is believed by many that organic farming is the much healthier and sustainable option. Although the health benefits of organic food are yet to be proven fully, consumers are willing to pay a higher premium for organic crops.

Many farmers in India are shifting to organic farming due to the domestic and international demand for organic food. Further stringent standards for non-organic food in European and US markets have led to the rejection of many Indian food consignments in the past. Organic farming, therefore, provides a better alternative to chemical farming.

Percentage of area under organic farming in the total cultivated area of different countries of the world (Source: Roychowdhury et al., 2013)

Country	**Percentage of area under organic Farming**
USA	0.23
UK	4.22

Germany	4.10
Argentina	1.70
Austria	8.40
Australia	2.20
Japan	0.10
Switzerland	7.94
South Africa	0.05
Italy	3.70
India	0.03
Pakistan	0.08
Srilanka	0.05

India produced around 5, 85,970 Mt of certified organic products including all varieties of food products. India exported 86 items in the year in 2007- 08 the total volume being 37533 Mt. The export realization was around US $ 100.4 million, registering a 30 per cent growth over the previous year. Organic products are mainly exported to EU, US, Australia, Canada, Japan, Switzerland, South Africa and the Middle East countries. Cotton leads among the products exported (16, 503Mt). The states of Uttarakhand and Sikkim have declared their states as organic states'. In Maharashtra, since 2003, about 5 lakh ha area has been under organic farming (of the 1.8 crore ha of cultivable land in the state). In Gujarat, organic production of chickoo, banana and coconut is being encouraged both from profit as well as yield point of view. In Karnataka, the area under non certified organic farming (4750 hectares) was substantially high as comparison to ha land was under certified organic farming (1513 hectares). The reasons behind this transition of shifting towards organic farming are sustained soil fertility, reduced cost of cultivation, higher quality of produce, sustained yields, easy availability of farm inputs and reduced attacks of pest and diseases. Apart from this, the government of Karnataka had released a state organic farming policy in 2004 for encouraging organic farming. Infect, most of the north-eastern states are also encouraging organic farming. In Nagaland, 3000 ha area is under organic farming. Also States like Rajasthan, Tamil Nadu, Kerala, Madhya Pradesh, Himachal Pradesh and Gujarat are promoting organic farming vigorously. Various farmers' organizations have been established in different states for the marketing of organic products. For example, the establishment of the Chetana'in three states: Andhra Pradesh (Asifabad and Karimnagar), Maharashtra (Vidarbha, Akola and Yavatmal) and Tamil Nadu (Dindigul and Tuticorn). However, there are indeed some constraints being faced by the farmers for transforming their conventional farming system into organic farming system. Lanting has identified some of the problems as follows: Non- payment of premium price for these products because they are in the transition stage, lack of storage facility, with cash paid (preferably 70% of the crop value) for the stored products. Here the urgency for the assistance from the government as a helping hand is of utmost importance for overcoming the barriers faced due to the transition from conventional farming to organic farming.

Status of organic food production in India

Total area under certified organic	**2.8 M ha**
Total production	585970 Million tonnes
Total quantity exported	19456 Million tonnes
Value of total export	Rs. 30124 lakh
Number of farmers	141904

Export performance of organic food products from India

Organic Food	**Sales (tons)**
Tea	3000
Coffee	550
Spices	700
Rice	2500
Wheat	1150
Pulses	300
Oil seeds	100
Fruits and vegetables	1800
Cashew Nut	375
Cotton	1200
Herbal Products	250
Total	11,295

Presently, organic food products exported from India include the following:

- Organic Cereals: Wheat, rice, maize or corn.
- Organic Pulses: Red gram, black gram.
- Organic Fruits**:** Banana, mango, orange, pineapple, passion fruit, cashew nut, walnut.
- Organic Oil Seeds and Oils: Soybean, sunflower, mustard, cotton seed, groundnut, castor.
- Organic Vegetables: Brinjal, garlic, potato, tomato, onion.
- Organic Herbs and Spices: Chili, peppermint, cardamom, turmeric, black pepper, white pepper, amla, tamarind, ginger, vanilla, clove, cinnamon, nutmeg, mace.
- Others: Jaggery, sugar, tea, coffee, cotton, textiles.

The Government of India is promoting organic farming through various schemes like

National Project on Organic Farming:- Under National Project on Organic Farming (NPOF) scheme, assistance upto 25% and 33% of financial outlay upto a ceiling of Rs. 40 lakhs and Rs. 60 lakhs respectively is provided as back ended subsidy through NABARD for establishment of bio- pesticides/bio¬fertilizers production units and agro waste compost production units respectively. Under NPOF, a total of 56 nos. biofertilizers production units and 17 nos. of fruit/vegetables waste compost units have been established in the country.

Government has been advocating integrating use of chemical fertilizers and organic manures including biofertilizers for increasing production of major crops.

National Horticulture Mission:- Besides, under National Horticulture Mission (NHM) and Horticulture Mission for North East & Himalayan States (HMNEH), financial assistance is provided for setting up vermi-compost production units @ 50% of the cost subject to a maximum of Rs. 30,000/- per beneficiary, for adoption of organic farming @ Rs.10,000/- per hectare for maximum area of 4 hectare per beneficiary and for organic farming certification @ Rs.5.00 lakh for a group of farmers covering an area of 50 hectares.

Rashtriya Krishi Vikas Yojna:- Assistance for promotion of organic farming on different components are also available under Rashtriya Krishi Vikas Yojana (RKVY) with the approval of State Level Sanctioning Committee.

National Food Security Mission:- Under National Food Security Mission (NFSM) on Pulses, including Accelerated Pulses Production Programme (A3P), assistance for popularizing Rhizobium culture/Phosphate Solubilising bacteria is provided to the farmers under cluster demonstrations.

Promoting the use of Biofertilizer:- Central Government has notified biofertilizers like Rhizobium, Azotobacter, Azospirillum, Acetobacter, PSB, KMB, Zinc Solubilizing bacteria under Fertilizer Control Order (FCO). Similarly, under Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP) Programme, Phosphate Solubilising Bacteria/Azotobacter culture is provided to the farmers as part of technology demonstration. Further, under National Project on Management of Soil Health and Fertility (NPMSH&F) financial assistance of Rs 500 per hectare is provided to promote use of organic manure.

ICAR Contribution in Promoting Organic Farming:- All India Network Project on Soil Biodiversity-Biofertilizers is implemented by Indian Council of Agricultural Research (ICAR) for R & D on biofertilizers. The ICAR has developed technologies to prepare various types of organic manures such as phosphocompost, vermi compost, municipal solid waste compost etc. Improved and efficient strains of biofertilizers specific to different crops and soil types are being developed under Network Project on biofertilizers.

The financial assistance is provided on the basis of project proposals received from States including Maharashtra. Indian Council of Agricultural Research (ICAR) under Network Project on Organic Farming, with lead centre at Project Directorate for Farming Systems Research Modipuram is developing package of practices of different crops and cropping system under organic farming in different agro-ecological regions of the country.

Advantages of Organic Farming

1. Organic manures produce optimal condition in the soil for high yields and good quality crops.

2. They supply the entire nutrient required by the plant (NPK, secondary and micronutrients).

3. They improve plant growth and physiological activities of plants.

4. They improve the soil physical properties such as granulation and good tilt, good giving good aeration easy rot penetration and improved water holding capacity.

5. They improve the soil chemical properties such as supply and retention of soil nutrient and promote favorable chemical reaction.

6. They reduce the need for purchased inputs.

7. Most of the organic manures are wastes of byproduct which accumulated load to pollution.

8. Organic fertilizer are considered as complete palnt food.

9. Organically grown crop are believed to provide more healthy and nationally superior food for man and animals that those grown with commercial fertilizers.

10 Organically grown plants are more resistant to disease and insect and hence only a few chemical sprays or other protective treatment are required.

11. There is an increasing consumer are willing to pay more for organic foods.

12. Organic farming helps to avoid chain reaction in the environment for chemical spray and dusts.

13. Organic farming helps to prevent environment degradation and can be used to regenerate degraded areas.

14. Since the basic aim is diversification of crops, much more secure income can be obtained that when they reply on only one crop or enterprise.

A Kitchen Gardening

Home or Kitchen Garden:- Cultivation of vegetables nearby the home or backyard of the house to produce the vegetables for the family throughout the year is usually termed as Home or Kitchen garden. The size of the kitchen garden depends on the availability of land and size of the family. The intensive cultivation is adopted for the kitchen garden to produce fresh vegetable year around.

Principles

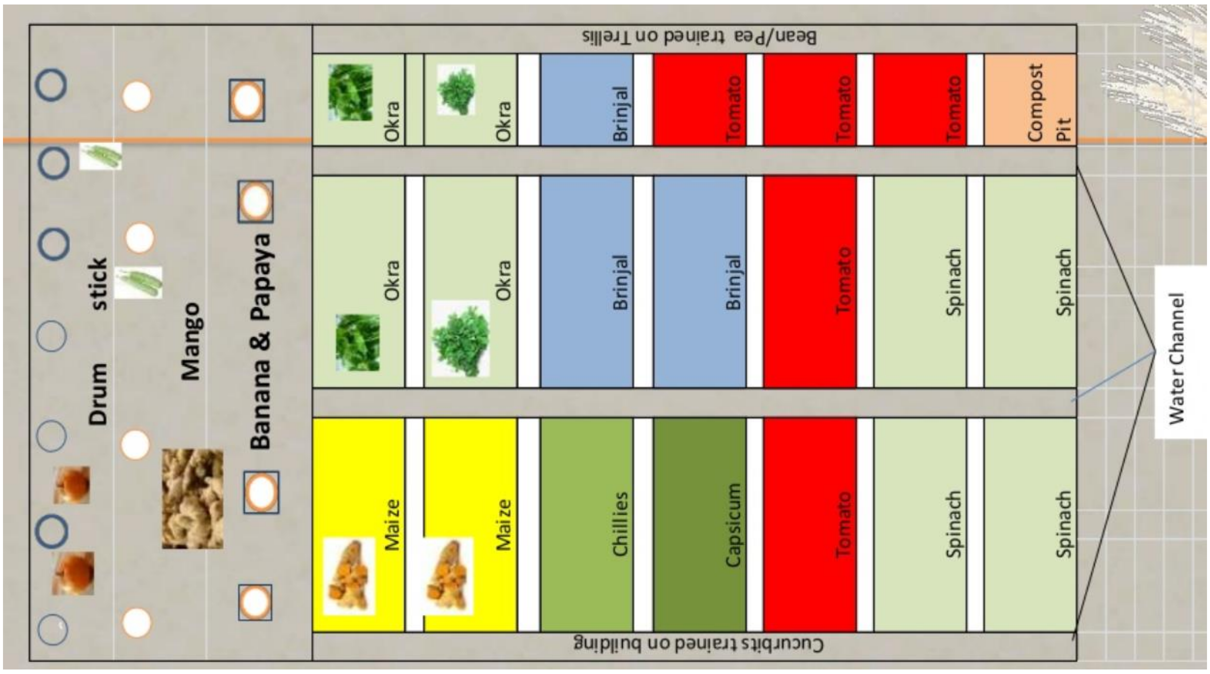
- Papaya, banana, grapes, lime, karonda are suitable fruit trees for kitchen gardening.
- The perennials and fruit plants like papaya, lemon, lime, karonda should be grown on the north side of the garden to avoid the shade effect on other crops.
- The vegetables like cucurbits and beans should be grown around the border and allowed to spread on the fence.
- The root crops like radish, turnip, carrot, etc should be raised on ridges.
- The land should not be left vacant and intensive crop cultivation should be followed with successive or companion crops.
- The proper crop rotation must be followed in the selection of vegetable crops.
- There should be a provision of compost pit in the corner of the kitchen garden.
- The stalking varieties of vegetables should be preferred for kitchen gardening.
- The proper planning including a selection of vegetable type and its varieties should be done before sowing to ensure a continuous supply of fresh vegetables full of nutrients without glut.
- For 5-6 members of family need 250-300m^2 area in kitchen garden.

- Maximum area cover in kitchen gardening from leafy vegetable.
- Under fruit tree should be planted shade loving plant like ginger, turmeric etc.
- Amrapali variety of mango and Pusa Nanha variety of papaya are suitable for kitchen gardening.

Advantages

- It provides an opportunity for recreation and exercise to family members.
- It improves Knowledge of family members about vegetable production.
- It is an ideal mean to convert leisure time into yields.
- It improves the standard of living by providing nutritious fresh vegetables and cutting down the expenditure on purchase of vegetables.
- It provides an opportunity for organic farming to get pesticides free vegetables.
- It creates a healthy green environment at the vicinity of home.
- It provides better pleasure, satisfaction, and reliability during eating of meals.
- The family can meet the sudden requirement of vegetables.

Layout of Kitchen Garden



Practice

Fill in the Blank

9. Area requirement in kitchen garden for single member of family?
a. $20m^2$ b. $50m^2$ c. $80m^2$ d. $100m^2$
10. Which is leading country in organic farming production?
a. India b. China c. USA d. Australia
11. Father of Organic Farming is?
a. Albert Howard b. Walter James c. Lord Northbourne d. Rudolf Steiner
12. Organic farming term coined by?
a. Albert Howard b. Walter James c. Lord Northbourne d. Rudolf Steiner
13. Which one is declared as a organic state?
a. Himachal Parades b. Uttarakhand c. Sikkim d. Madhya Parades

Descriptive

1. Write down the short note on present status of organic farming in India.
2. What is organic farming and why it is present need?
3. Which incidence introduce chemical farming in India.
4. Draw the layout of Kitchen Gardening?
5. Write down the summery of national food security mission.

UNIT III: Post-Harvest Management

IMPORTANCE, SCOPE OF POST-HARVEST TECHNOLOGY AND PROCESSING

India is a second largest producer of fruits and vegetables after China these are share 10% or 16% respectively in total world production and is the leader in several horticultural crops, namely mango, banana, papaya, cashew nut, areca nut, potato, and okra (lady's finger). Horticulture crops occupy 24.472 million ha. and production is estimated around 286.188 million tones. Total area of fruits, vegetable, plantation crops, spices, loose flower and aromatic plant are 6301, 10106, 3680, 3474, 278 and 634 thousand ha, respectively and production are 90186, 169064, 16658, 6988, 2184 and 1022 thousand tones, respectively with productivity are 11.32, 17.22, 4.54, 1.87, 6.59, 1.19 thousand tones per ha, respectively (2015). The total productions of cut flowers are 74305 Lakh stem (2012-2013). During 2015-16, India exported fruits and vegetables worth Rs. 8,391.41 crores which comprised of fruits worth Rs. 3,524.50 crores and vegetables worth Rs. 4,866.91 crores. . In terms of volume, fresh fruits & vegetables comprised about 76 % of exported horticulture produce followed by processed fruits & vegetables (23 %) and floriculture & seeds (1%). After that losses found 20-30 % in fruit and 30-40 % in vegetable while harvesting to consumption in India. It's due to the perishable nature of horticulture commodity, non-availability of appropriate post-harvest infrastructure transportation, inadequacy of the market or lack of processing.

India is a main horticulture producer even though processing only less than 2 % which is very low as compare to 80 % of Malaysia, 78 % of Philippine, 70 % of Brazil and 30 % of Thailand. The most of developed country 40-60 % fruits and vegetables utilize in processing.

Proper handling, packaging, transportation and storage reduce the post harvest losses of fruits and vegetables. For every one percent reduction in loss will save 5 million tons of fruit and vegetable per year. Processing and preservation technology helps to save excess fruit and vegetable during the glut season. The technology has become a necessity to improve the food safety and strengthen nations food security. The technology helps to boost export of agricultural commodities in the form of preserved and value added products.

- **Food processing industries could be divided into four group, based on their capacity of production:**
  - **A.** Large scale unit ›250 t/year
  - **B.** Small scale unit 50-250 t/year
  - **C.** Cottage scale unit 10-50 t/year
  - **D.** Home scale unit ‹10 t/year
- **Estimated post-harvest losses of fruit and vegetables**

S. No.	Fruit/Vegetable	Percent loss
1.	Papaya	40-100
2.	Mandarin	20-95
3.	Banana	20-80
4.	Grape	27

5.	Lemon	20-85
6.	Cauliflower	49
7.	Tomato	5-50
8.	Onion	16-55
9.	Cabbage	37
10.	Potato	5-40

❖ **Indian production of processed fruits & vegetables**

Product	% Share
Fruit pulp & juice	27
Ready-to-serve beverages	13
Pickles	12
Jams & jellies	10
Synthetic syrups	8
Squashes	4
Tomato puree & ketchup	4
Canned vegetables	4
Others	18

❖ **Indian processing industry profile**

Industry	Share %
Unorganized	42%
Organized	25%
Small scale	33%

❖ **India export of process products to different country**

Product	Country
Mango Pulp	Saudi Arabia, UAE, UK, USA
Fruit Juice	USSR
Canned Fruit (mango, guava)	USSR, UAE
Canned vegetable (Green pepper)	UK, USA, UAE
Dehydrated (Garlic, Onion)	USSR, Japan, UK
Pickles, Chutney (mango)	USA, Japan, USA

History

- The first recorded cause of spoilage in stored food by Needham (1749).
- Iron container was discovered by Aes the bptngusts de Heine (1800).
- Peter Durand(1800) discovered the metal container.
- Fermentation firstly recorded by Lovoisier in 1789.

- Spallanzani (1765) disputed the theory of preservation by mean of heating. This constitutes the basic principle of canning.
- M. Nicholos Appart (1804) was the first to report the successful preservation of food in glass container. He is known as 'Father of Canning'.
- Fastier (1824) discovered the Hold the Cap Can.
- Cooking of food by mean of preserve started by Papin in 1861.
- Autoclave firstly used by Shriver in 1874.
- Modern refrigeration discovered by James Haryson in 1857.
- Fruit and Vegetable processing was Ist started in organized manner in 1857.
- In India, the first fruit and vegetable processing factory was established in 1920 at Mumbai.
- The Central Food Technological Research Institute was establish at Mysore in 1950.
- Fruit Preservation and Canning Institute was established at Lucknow in 1949.
- Burg and Burg (1966) discovered the hypobaric storage.

Practice

Fill in the Blank

1. …………………………was the first to report the successful preservation of food in glass container. He is known as 'Father of Canning'.
2. Autoclave firstly used by …………………in 1874.
3. The first recorded cause of spoilage in stored food by ……………..(1749).
4. Fermentation firstly recorded by ……………. in 1789

Descriptive

1. Write down the present status of processing in India.

POST-HARVEST MANAGEMENT OF FRUITS AND VEGETABLES

Fruits and vegetables are living tissues subject to continuous change after harvest. Some changes are desirable from consumer point of view but most are not. Post-harvest changes in fresh fruit cannot be stopped, but these can be slowed down within certain limits to enhance the shelf life of fruits. The post-harvest handling plays an important role in extending the storage and marketable life of horticultural perishables.

Post-Harvest Treatment of Fruits and Vegetables Washing

It is useful in removing surface adhering material water. Mechanically, it is also accomplished by passing the fruits/vegetables through machine arranged with water tank equipped with rotating brush. In some produce washing improves appeal by facilitating removal of sap as case in mango, papaya, jackfruit, kronda, dirt in case of carrot, reddish, turnip, sugar beet, sweet potato, etc. and for removal of debris in case of banana. The water use for the purpose should be cleaned otherwise fungal and bacterial levels may build up. Disinfected treatment using ultraviolet light, ozone, chlorine, calcium hydroxide, etc. help to clean water for washing purpose.

Pre-cooling

It refers to the repid removal of the field heat from freshly harvested horticultural produce in order to slow ripening and senescence, conserve weight and reduce deterioration prior to storage and transport. Pre-cooling is accomplished by hydro cooling (immersing in water), contact icing (Placing cursed ice in or on the package), vaccum cooling (rapid evaporation of water at low presser to effect cooling) and air cooling (cooling based on refrigeration system).

List of commodity-wise cooling method

S.No	Cooling Method	Commodity
1	Room Cooling	All fruits and vegetables
2	Forced Air Cooling (Pressure Cooling)	Fruits and fruit type vegetables, tubers and cauliflower
3	Hydro Cooling	Stem and leafy vegetables, some fruits and fruit type vegetables
4	Package Icing	Roots, stem, some flower type vegetables, green onion and brussel sprouts
5	Vacuum Cooling	Some stem, leafy and flower type vegetables
6	Transit Cooling, Mechanical refrigeration	All fruits and vegetables
7	Top Icing and Channel Icing	Some roots, stem, leafy vegetable and cantaloupes

Curing

Curing done for root, tuber and bulb crops in which holding the produce at high temperature and high relative humidity for several days while harvesting wounds heal and a new, protective layer of cells form. While curing can be initially costly, the long extension of storage life makes the practices economically worthwhile.

S.No.	Commodity	Temperature (^{0}C)	Relative Humidity (%)	Curing Time (days)
1	Potato	15-20	90-95	5-10
2	Sweet Potato	27-33	>90	5-7
3	Yam	32-40	>90	1-4
4	Taro	30-35	>95	4-7
5	Cassava	30-35	>80	4-7
6	Onion and Garlic	35-45	60-75	0.5-1

Degreening

The process of decomposing the green pigment in fruits by applying ethylene (10-20ppm) at 27^{O}C and 80-90% or similar metabolic inducers to give a fruit to its characteristic colour as preferred by consumers, generally followed in citrus fruit but also practiced in banana, mango, tomato, etc.

Sorting

It is the process of separation of commodities into different categories on the basis of measurable physical properties. It also helps in removing of unwanted material or diseased portions.

Grading

Separation of commodity for getting maximum benefit on the basis of uniformity is termed as grading. It is an important aspect of quality as the product is rated on the basis of homogeneity of lot. Grading is done on the basis of size, shape, weight, colour, texture, firmness, composition, defects, etc.

Waxing

Waxing of fruits or vegetables is a common post-harvest practice. Food grade waxes are used to replace some of the natural waxes removed during harvesting and sorting operations and can help to reduce water loss and respiration during handling and marketing. It also helps in sealing tiny injuries and scratches on surface of fruits and vegetables. It improves cosmetic appearance and prolongs the storage life of fruits and vegetables. The wax coating must be allowed to dry thoroughly before packing.

Hot Water Treatment

Immersing the produce in hot water before storage/marketing is known as hot water treatment. It is effective in minimizing fungal diseases. Anthracnose in fruit can be controlled by dipping the fruit in hot water at 51-55^{0}C for 30 minutes. This treatment helps in attaining uniform ripening within 5-7 days.

Hot water treatments for different fruits

Commodity	Pathogens	Temp.(°C)	Time (min)
Apple	*Gloeosporium sp.* *Penicillium expansum*	45	10
Grapefruit	*Phytophthora citrophthora*	48	3
Lemon	*Penicillium digitatum* *Phytophthora sp.*	52	5-10
Mango	*Collectotrichum gloeosporioides*	52	5
Orange	*Diplodia sp.* *Phomopsis sp.* *Phytophthora sp.*	53	5
Papaya	*Fungi*	48	20
Peach	*Monolinia fructicola* *Rhizopus stolonifer*	52	2.5

Source: Lisa Kitinoja and James Gorny, 1998

Radiation Treatment

Subjecting the produce to ionizing radiation is referred to as radiation. It acts in pasteurization of surface. Hence, the technique is also known as radurization. As it works without raising temperature of produce, it is known as cold sterilization. It has its role in surface pasteurization, sprout inhibition and retardation of senescence process. Radiation can destroy pathogen/pest without raising the temperature of the produce.

Government of India approvals for Irradiation dose requirements for fruits and vegetables

Commodity	Irradiation dose (KGy)		
	Minimum	Maximum	Purpose
Onion	0.03	0.09	Sprout inhibition
Potatoes	0.05	0.15	Sprout inhibition
Raisins	0.25	0.75	Insect disinfestations
Dried fruits	0.25	0.75	Insect disinfestations

Mango	0.25	0.75	Shelf life extension and quarantine treatment, Fruit fly and stone weevil disinfestations
Ginger	0.03	0.15	Sprout inhibition
Garlic	0.03	0.15	Sprout inhibition
Small onions (shallots)	0.03	0.15	Sprout inhibition

Vapour heat treatment (VHT)

This treatment proved very effective in controlling infection of fruit flies in fruits after harvest. The boxes are stacked in a room, which are heated and humidified by injection of steam. The temperature and exposure time are adjusted to kill all stages of insects (egg, larva, pupa and adult), but fruit should not be damaged. A recommended treatment for citrus, mangoes, papaya and pineapple is 43^0C in saturated air for 8 hours and then holding the temperature for further 6 hours. VHT is mandatory for export of mangoes.

Fumigation

In this technique place the boxes of fruit in a gas (SO_2) tight room and introducing the gas from a cylinder to the appropriate concentration. However, special sodium metabisulphite pads are also available which can be packed into individual boxes of a fruit to give a slow release of SO_2. The primary function of treatment is to control the *Botrytis Cinerea*. The SO_2 fumigation is also used to prevent discolouration of skin of litchis.

Fumigation with 1.2% sulphur dioxide for 10 minutes was shown to be effective in reducing skin discolouration in fresh litchis, especially if it is combined with a 2 minute dip in HCl acid directly afterwards. Immediately after sulphur dioxide treatment litchi fruit may appear a uniform yellow colour and then turn red again after 1 or 2 days.

Chemical Treatment

- The fungicide, chemical and growth regulators are used to extend shelf life of fruits.
- Pre harvest treatment of Maleic Hydrazide (200 ppm) reduces sprouting of onion and potatoes during storage.
- Potassium permanganate is used as ethylene absorbent in packaging of fruits which delay ripening.
- Post harvest dip with Diphenylamine (0.1-0.25%) for 30 seconds controle superficial scald.
- Ripening of banana and tomato can be delayed by post harvest treatment with Gibberellic acid.
- Pre harvest spray of N-Benzyladenine(BA) 10-20 ppm prolong shelf life of vegetables.
- Maleic hydrazide @ 1000-2000 ppm delays ripening of mangoes.
- Pre-harvest spray of calcium chloride (0.6%) and calcium nitrate (1%) resulted in enhancement of shelf life of mangoand guava fruits.

- Treatment of mature green guava fruit with GA_3 at 100-200 ppm help extends the storability of fruits.
- Pre harvest treatment of ber with Calcium compounds (1.7%) solution is useful in delayed fruit ripening.
- Storage life of leafy vegetables can be extended following post harvest application of Cytokinin.
- Treatment of legumes vegetables with Indol Acetic Acid (IAA) solution is useful in maintaining green colour.
- Pre harvest spray of 0.2% Difolatan control post harvest diseases of tomato and onion.

Storage

Proper marketing of perishable commodities such as fruit and vegetables often requires some storage to balance day-to-day fluctuation between harvest and sale or for long term storage. Storage of horticulture produce is attempeted with a view to extend period of availability. Storage controls shelf life of produce by controlling rate of respiration, transpiration, ripening and biochemical changes all of which are responsible for shelf decomposition/deterioration of produce. Further, different types of storage have different attributes in minimizing microbial infection and thus add to better storability of produce.

Objective of storage

- Slow the biological activity and micro-organism growth.
- Avoid glut and distress sale in the market, thus prolonging the market period.
- In long-term storage, making the food available in off-season.
- Regulate the market in an orderly manner.
- Reduce the transpirational, respiration, and ethylene production rate.

Tips for storage of high quality horticultural produce

- Store only high quality produce, free of damage, decay and of proper maturity (not over-ripe or under-mature).
- Knowledge of the appropriate storage conditions.
- Avoid lower than recommended temperatures in storage, because many commodities are susceptible to damage from freezing or chilling.
- Do not over load storage rooms or stack containers closely.
- Provide adequate ventilation in the storage room.
- Keep storage rooms clean.
- Storage facilities should be protected from rodents by keeping the immediate outdoor area clean, and free from trash and weeds.
- Containers must be well ventilated and strong enough to with stand stacking. Do not stack containers beyond their stacking strength.
- Avoid storing ethylene sensitive commodities with those that produce ethylene.
- Avoid storing produce known for emitting strong odors (apples, garlic, onions, turnips, cabbages and potatoes) with odor-absorbing commodities.
- Inspect stored produce regularly for signs of injury, water loss, damage and disease.
- Remove damaged or diseased produce to prevent the spread of problems.

Factors Affecting of Storage

1. Temperature
2. Relative Humidity
3. Ventilation
4. Air Velocity
5. Atmospheric gases composition
6. Light
7. Commodities
8. Post Harvest Treatment

Storage Method

1. Traditional Storage
2. Advanced Storage

Traditional Storage

a) Pit Storage
b) Clamp Storage
c) Barns Storage
d) Cellars Storage
e) Sand and Coir Storage
f) High Altitude Storage
g) Zero Energy Cool Chamber

Zero Energy Cool Chamber

The zero energy cool chamber used to enhance the shelf life of fresh fruit and vegetables by maintaining the temperature and relative humidity during summer and winter suasion naturally with the application of water. It is based on the principle of direct evaporation cooling and hence, does not require any electricity or power to operate, and all the material (Brick, sand, bamboo, khaskhas, etc.) required to make the cool chamber are available easily and are reusable. For zero energy cool chamber construction upland is selected where there is a lot of aeration and should be near to the source of water supply and floor (165 cm x115cm) is made by bricks. A double wall is erected upto a height of 67.5 cm and leaving a cavity with approximately 7.5 cm space between the inner and outer brick walls. The cavity (7.5 cm) between the double walls is filled with sand and drenched with water. A lid (165cmx115cm) is made using straw/ dry grass on bamboo frame. The shed is made over the chamber in order to avoid direct sun or rain.

The whole structure is made wet by sprinkling water daily twice (morning and evening) in order to achieve desired temperature and relative humidity or fix a drip system with plastic pipes and micro tubes connected to an overhead water source. The horticultural produce is kept in perforated plastic crates covered with a thin polyethylene sheet. Maximum and minimum thermometer and hygrometer are placed in the chamber to note temperature and relative humidity, respectively

Shelf life of fruits and vegetables in zero energy chamber (days)

Produce	Time of storage	Outside	Cool chamber
Leaf vegetables	Summer	<1	3
Leaf vegetables	Winter	3	8-10
Potato	Spring/Summer	40	97
Mango	Summer	4	8

Orange	Winter	8-10	20-30
Tomato	Summer	7	15
Pointed gourd	Summer	2	5
Bitter gourd	Summer	2	6
Okra	Summer	1	6
Carrot	Spring	5	12
Cauliflower	Spring	7	12
Green chilli	Summer	3	6

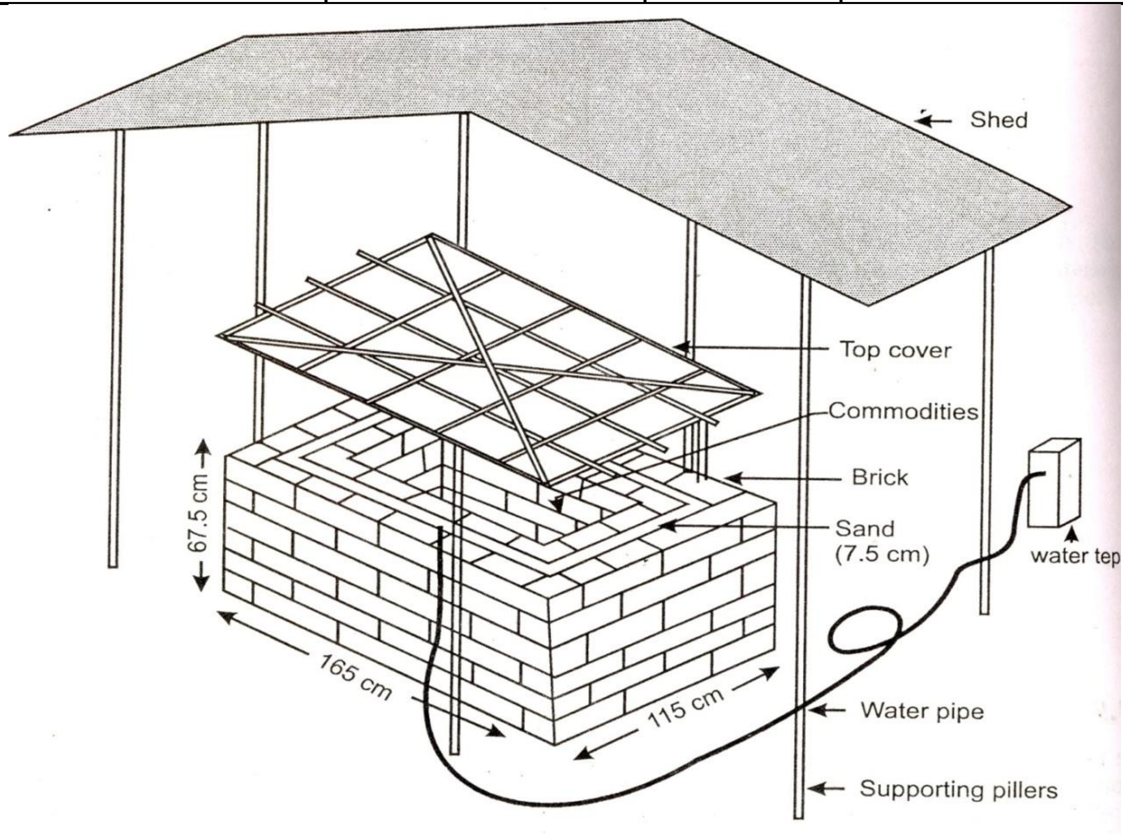


Fig. . . Zero Energy Cool Chamber

Advanced Storage

A. Cold Storage

It maintains low temperature and humidity throughout the storage period. Temperature which is just sufficient to lower down metabolic activity of produce is maintained. Care is taken that the inside temperature may not cause chilling injury to the produce. Depending upon type of produce different temperature and humidity are maintained under cold storage.

Recommended temperature and relative humidity conditions for fruits storage

Name of commodity	Temp (^{O}C)	RH (%)	Approximate Shelf-Life
Acid lime,	8-10		6-8 weeks
Apple	-1-0	90-95	4-8 months

Apricot	0-1	90-95	1-2 weeks
Asian pear	0-1	90-95	2 months
Avocado	8-12	85-90	1.5 weeks
Banana	13	90-95	1-4 weeks
Ber	3	90-95	4 weeks
Fig	0-1.7	85-90	7weeks
Date	6.7	85-90	2 weeks
Grape	0-1	90-95	2-8 weeks
Guava	8-10	90-95	2-3 weeks
Kiwi, Chinese gooseberry	0	90-95	3-5 months
Lemon	10-13	85-90	1-6 months
Loquat	11	90	3 weeks
Lychee, Litchi	5.7	90-95	3-5 weeks
Mandarin (Kinnow)	8-10	90-95	2 months
Mango	8-9	85-90	2-4 weeks
Mangosteen	4-6		2-3 weeks
Nectarine	-0.5-0	90-95	2-4 weeks
Papaya	9-10	90-95	1-3 weeks
Passion fruit	5.6-7.2	85-90	3 weeks
Peach	0-0.3	90-95	2-4 weeks
Pear	-1.5-0.5	90-95	4-5months
Persimmon	0-1.7	85-90	7 weeks
Pineapple	7-13	85-90	2-4 weeks
Plum and prunes	0-1	90-95	2-5 weeks
Pomegrante	5	90-95	2 months
Strawberry	0	90-95	7-10 weeks
Sweet cherries	-1-0.5	90-95	2-3 weeks
Sweet Orange	2-5		2-3 month

Recommended temperature and relative humidity conditions for vegetables storage

Name of commodity	**Temp (^{o}C)**	**RH (%)**	**Approximate Shelf-Life**
Asparagus, green	1-2	95-100	2-3 weeks
Beans	4-7	90-95	7-10 days
Bell Pepper	7-10	90-95	2-3 weeks
Bitter gourd	10-12	85-90	2-3 weeks
Brinjal	10-11	92	3-4 week
Broccoli	0	95-100	10-14 days
Cabbage	0	90-95	3-6 weeks
Carrots	0.4-4	93-99	6-8 months
Cauliflower	0	90-95	3-4 weeks
Eggplant	10-12	90-95	1-2 weeks
Garlic	0	65-70	6-7 months
Ginger	13	65-70	6 months
Lettuces	0	90-95	2-3 weeks
Mushrooms	0	90	7-14 days

Okra	8.9	90-95	7-10 days
Onion	0	65-70	20-24 weeks
Peas	0	90-95	1-2 weeks
Potato	3-4.4	85	34 weeks
Radish	0	90-95	1-2 months
Tomato (Ripe) (Unripe)	7.2 8.9-10	90 85-90	1weeks 4-5 weeks
Turnip	0	90-95	4-5 months
Watermelon	10-15	90-95	2-3 weeks

Hypobaric Storage

In such type of storage, the produce is storage under low pressure atmosphere, vacuum tight and refrigerated condition. The pressure of 1.3 to 13 kPa is maintained under storage. The due to lowering of pressure under storage, the pressure of individual gases are lowered. The CO_2 and other volatiles like ethylene produced during respiration in course of storage are removed and controlled level of O_2 is maintained. Many time flavour of the produce is affected.

Controlled atmosphere (CA) storage

Storage of commodities under gaseous atmosphere condition, like gas storage, where the composition of atmosphere is controlled accurately. Thus the levels of carbon dioxide, oxygen, nitrogen, ethylene, and metabolic volatiles in the atmosphere may be manipulated. Controlled atmosphere storage generally refers to keeping produce at decreased oxygen and increased carbon dioxide concentrations and at suitable range of temperature and RH. The modified atmosphere and controlled atmosphere differ only in degree of control and CA is more exact. This storage method in combination with refrigeration markedly enhances storage life of fruit and vegetables.

Benefits of CA storage

- Slow down respiration and ethylene production rates, softening and retard senescence of horticultural produce.
- Reduce fruit sensitivity to ethylene action
- Alleviate certain physiological disorders such as chilling injury of various commodities, russet spotting in lettuce and some storage disorders including, scald of apples.

Harmful effects of CA storage

- Initiation or aggravation of certain physiological disorders can occur, such as blackheart in potatoes, brown stain on lettuce and brown heart in apples and pears.
- Irregular ripening of fruits, such as banana, mango, pear and tomato, can result from exposure to O_2 levels below 2% or CO_2 levels above 5% for more than 2 to 4 weeks.
- Off- flavors and off-odours at very low O_2 or very high CO_2 concentration may develop as a result of anaerobic respiration and fermentative metabolism.

Modified Atmospheric Storage (MA)

Storage in which inside atmosphere is modified in such a way that its composition is other than that of air constitutes MA storage. The modification is achieved by manipulating O_2, CO_2 and N_2 is storage atmosphere. It favoures extension in self life of produce owing to reduced respiration and ethylene production, minimize water loss and nutrient decomposition, reduced microbial growth and spoilage and inhibition of ripening and senescence.

POST-HARVEST MANAGEMENT OF FLOWERS

Flowers are highly perishable unlike other horticultural or agricultural crops. Owing to poor keeping quality the post-harvest losses in floriculture are significantly higher than any other sector. Although there has been significant increase in the area, production and productivity of flower crops in the last two decades, there is an urgent need to minimize the huge post-harvest losses in terms of the value of the produce which are estimated to be 30-40 per cent of farm value. The post-harvest behavior of flowers is an outcome of the physiological processes, occurring in leaves, stem, flower bud, leafless peduncle or scape connecting bud to the stem. Some of these processes may act independently to affect the senescence and vase life of cut flowers but most of them are inter-related. The nature and extent of post-harvest damage is typical for each crop or cultivar. The post-harvest losses become important especially when dealing with the export of fresh flowers to distant and foreign market. Therefore, patient, soft and expert handling of flowers is of utmost importance after harvest.

The post-harvest quality of flowers depends upon mainly three factors.

1. Pre harvest factors
2. Harvest factors
3. Post-harvest factors

Pre-Harvest Factors

Genetic or inherent makeup

Post-harvest lasting quality of flower species and cultivars vary considerably due to differences in their genetic make-up. Gladiolus varieties White Prosperity, Sancerre, Suchitra, Eurovision, Nova Lux, Rose Supreme and Trader Horn possess the better vase-life.

Growing conditions

Most cut flower crops require well-lighted conditions. On the contrary, too high light intensities cause scorching and dropping of leaves and abscission of petals. Flower crops are also specific in their temperature requirements. Flowers also require adequate nutrients for good longevity. High nitrogen doses should be avoided as they increase susceptibility to diseases. For example, iron deficiency is commonly observed in gladiolus in north India, causing heavy yield losses. Flowering crop should also be grown away from the industries which release toxic effluent, gases, damaging the foliage as well as flowers. Flowers damaged by pathogens, insects and pests also show high ethylene production resulting in poor vase-life.

Harvest Factors

The most important factors for harvest are when, how and where, “when” the plant material will reach the optimum stage of development and “when” during the day to harvest. Each plant material has its own best harvest stage and this can vary depending on the use of, and market for, the plant material. Materials for preserving usually are harvested more mature than those for fresh, wholesale markets. Some general rules of thumb for when to harvest are, spike type flowers harvest when one-fourth to one-half of the individual florets are open; daisy type flowers- harvest when flowers are fully open. The other “when” is, the best time of day for harvesting flowers is coolest part of the day and when there is no surface water from dew or rain on the plants.

Right stage, method and time of harvesting of flowers are of considerable importance to ensure their long vase-life. The stems should be cut with sharp knives or secateurs. Hardwood stems should always be given slanting cut to expose maximum surface are to ensure rapid water absorption. The flowers of dahlia and poinsettia release latex upon cutting. To overcome such problem, stems should be given a dip in hot water (80-90^{0}C) for a few seconds.

The flowers of rose, carnation, gladiolus, tuberose, daffodils, lily, iris, freesia and tulip should be harvested at bud stage since their buds continue to open in water. The flowers of snapdragon, Harvesting of flowers at bud stage is always preferred as their buds have long vase-life, are less sensitive to ethylene, easy to handle during storage and transport and are less prone to diseases and pests.

Harvesting stages for important Flowers

S.no.	**Flower**	**Harvesting stages**
1.	Rose	For local market: when outer one/two petals start unfurling For distant market: fully coloured tight buds Loose flower: fully open flower
2.	Carnation (standard)	For local market: when flower are half opened or at paint brush stage or outer petal is perpendicular to stem For distant market: cross is developed on buds and colour is visible
	Carnation (spray)	For local market: when two flowers have opened and other heve shown colour For distant market: when 50% flower have shown colour. Loose flower: fully open flower
3.	Chrysanthemum (standard)	For local market: half opened flowers For distant market: when outer row of florets start unfurling
	Chrysanthemum (spray)	For local market: when two flowers have opened and other shown colour For distant market: when 50% flowers have shown colour
	Chrysanthemum (loose flower)	Fully open flower
	Pot mums	50% buds have developed colour
4.	Gladiolus	For local market: lower most 1-2 florets are opened

		For distant market: lower most 1-2 florets show coloure
5.	Oriental lily	For local market: when 1-2 florets are opened For distant market: when 1-2 florets show coloure
6.	Asiatic lily	For local market: when 1-2 florets are opened For distant market: when 1-2 florets show coloure
7.	Gypsophilla	25-30% flowers are fully open in the inflorescence
8.	Tuberose	Single: buds are fully developed but yet not open Double: basal 3-4 buds start to open
9.	Orchids	Most species: fully open flowers Dendrobium: 75% inflorescence is open
10.	Anthurium	When one thred to one half of the spedix shows change in colour (mature)
11.	Alstroemeria	For local market: when 4-5 florets have opened For distant market: when first floret has started opening and other have developed 50% colour
12.	Gerbera	Before outer row of ray florets show pollen or when outer row of petals is perpendicular on stalk
13.	Marigold	Fully open flowers
14.	Calendula, pot marigold	Fully open flowers
15.	China aster, annual aster	Fully open flowers
16.	Cockscomb	One-half florets open
17.	Daffodil, narcissus, jonquil	“goose neck” stage
18.	Dahlia	Fully open flowers
19.	Delphinium	One-half florets open
20.	Freesia	First bud beginning to open
21.	Goldenrod	One-half florets open
22.	Larkspur, annual delphinium	

23.	Lily-of-the-valley	One-half florets open
24.	Nasturtium	Fully open flowers
25.	Pansy	Almost open flowers
26.	Snapdragon	One-third florets open
27.	Sweet pea	One-half florets open
28.	Sweet William	One-half florets open
29.	Zinnia	Fully open flowers

Post-Harvest Factors

Water relations

The termination of life of the harvested flowers depends on water uptake and transport, water loss and the capacity of the flower tissue to retain its water. A water deficit and wilting develop, when the transpiration exceeds absorption of water. The rate of water uptake of cut flowers depends on transpiration pull, temperature and composition of solutes . Disruption of water columns in stem vessels by air embolism and resistance to water flow in stems, also develop water deficit. Acidification of water and addition of wetting agent and flower food in the holding solution markedly improve water uptake of cut flowers.

Respiration

The rate of respiration depends on quantity of carbohydrates available in the harvested flowers, temperature and the use of certain chemicals to regulate it. With higher temperature, there is faster rate of respiration and burning of the tissue. Consequently, the life of flowers is shortened.

Relative humidity

It has, bearing on the transpiration rate. Higher the humidity in the air, less is the transpiration rate and vice-versa.

Growth regulators

Postharvest life of flowers can be controlled by growth regulators. Water relation changes associated with flower senescence are also influenced by growth regulators. Cytokinins delay senescence of some cut flowers. Depending upon the concentrations, GA in some cases promotes longevity of flowers, while this is also used in bud opening solution. The IAA promotes ethylene production of isolated carnation petals. In contrast, the senescence and abscission of poinsettia flowers is delayed by auxin.

Preservative solutions

Preservatives in the form of tablets or powder are prepared from a mixture of chemicals-sugars, germicides, salts and growth regulators. Various types of conditioners are sugar and biocide, antiethylene compound, and hydrated compound. The flowers like gladiolus, carnation, chrysanthemum and freesia are benefited most by the pretreatment.

Antiethylene compounds in preservative solutions reduce the action of ambient ethylene as well as autocatalytic production of ethylene by fresh cut flowers. Fresh cut flowers responding to silver thiosulphate are carnation, orchids, gypsophila, gladiolus, gerbera, snapdragon, alstromaeria, agapanthus, anemone and sweet pea. Greatest improvement in cut flower quality and longevity is obtained when DICA or DDMH were combined with sucrose.

Pre-cooling and storage

Precooling is essential for removing field heat from flowers. This is done either by forced air cooling or hydrocooling to bring down temperature from 20^0-30^0C to 1^0C in a relatively short period. Other methods are room cooling and vacuum cooling. Flowers can be stored for a longer period at low temperature. There are two methods of cold storage-wet and dry. Wet method is short-term storage, in which cut stems are dipped in water. Dry storage is more labour-intensive method and costly. The controlled atmosphere based on reduction of respiration rates, conservation of respirable substrates during, storage, and delay in ethylene-triggered changes cause senescence. It involves the use of increased level of CO_2 and decreased levels of O_2 in the atmosphere, low storage temperature and prevention of the build-up of endogenous ethylene.

Packing and transporting

Lower rate of transpiration, respiration and cell division during transportation, are essential for long storage life and keeping quality. Before packing, flowers should be dried. They should be treated with systemic insecticides and miticides. Packing must ensure protection of flowers against physical damage, water loss and external conditions detrimental to transported flowers. Boxes made of corrugated fibre boards are good. Flowers sensitive to geotropic bending must be transported in an upright position. The flowers should be transported at an optimal low temperature. The relative humidity of the air during precooling and shipment of cut flowers should be maintained at the level of 95-98%. Lack of light during prolonged transportation particularly at high temperature causes yellowing of leaves in many flowers. Shipment of flowers is usually done by road, air and sea. For short distance and time period shorter than 20 hr, cut flowers may be transported in insulated trucks without refrigeration after precooling and proper packing. Air shipment is quickest and usually the temperature is not controlled during the flight the flowers should be pulsed with STS prior to air shipment

Post harvest treatment of cut flowers for improve shelf-life

Pre-cooling

Precooling is a treatment given to flowers to remove the field heat immediately after harvest. It can be done with ice cold water, cold water or forced air. Pre-cooling reduces respiration rate and decreases breakdown of nutritional and other stored material in the steam, leaves and patals, delays bud opening and flower senescence. It also delays rapid water loss and decreases flower sensitivity to ethylene.

Pre-cooling temperature of some important flowers

S.no.	Flower	Pre-cooling Temperature
1.	Alstroemeria,	4^0C

	Gladiolus	
2.	Anthurium	13^0C
3.	Dendrobium	$5\text{-}7^0C$
4.	Carnation	1^0C
6.	Rose	$1\text{-}3^0C$
7.	Chrysanthemum	$0.5\text{-}4^0C$
8.	Cymmbidium	$0.5\text{-}4^0C$

Conditioning/ hardening

It restores the turgor of flowers wilted after harvest, storage or transport. Conditioning is done with dematerialized water supplemented with germicides and acidified with citric acid to pH 4.0-5.0. Some wetting agents like tween 20 @ 0.01-0.10% can be used for this purpose. Some chemical like STS, 8-HQC, sucrose etc can also be used for conditioning.

Impregnation

Loading of flowers with high concentration of silver nitrate or nickel chloride of cobalt chloride for a short period of time is known as impregnation. It protects the blockage of the water vessel in stem by microbial growth and decay and synthesis of ethylene. It is generally practice in crops like Gerbera, Carnation, Chrysanthemum and Gladiolus cut flowers.

Pulsing

Treating the flowers with high concentration of sucrose and germicide for a short period of time, in order to improve the shelf life and to promote flower opening. Pulsing is beneficial especially for flowers destined for long storage period or long distance transportation. The addition of sucrose in the vase water alone, may encourage increased growth of micro-organisms in the vase medium. Hence, the antimicrobial agents eg 8-HQ, 8-HQS, 8-HQC, silver salts, citric acid etc should also be incorporated to enhance better solution uptake that would suffice maximum effects of the supplied sugar.

- Sucrose is the main ingredient of pulsing solutions providing additional sugar, and the proper concentration range from 2 to 20%, depending on the crop. The solution should always contain a biocide appropriate for the crop being treated.
- Ethylene-sensitive flowers are pulsed with silver thiosulphate (STS). Treatments can be for short periods at warm temperatures (e.g. 10 minutes at 20^0C) or for long periods at cool temperatures (e.g. 20 hours at 2^oC).
- Alstroemeria and lilies can be pulsed in a solution containing gibberellic acid to prevent leaf yellowing, and this is often a useful pre-treatment.
- Short pulses (10 seconds) in solutions of silver nitrate useful for some crops. China asters and maidenhair fern respond well to solutions containing 1000 ppm silver nitrate. Other flowers are damaged by these high concentrations, but respond well to 100-200 ppm (e.g. gerberas). The function of the silver nitrate is not fully understood. In some cases it seems to function strictly as a germicide (e.g. chrysanthemums). In

all cases, residual silver nitrate solution should be rinsed from the stems before packing.

- Generally for rose and carnation, 5-8% sucrose solution is sufficient while for multi-floret spike like gladiolus and tuberose, high concentration of 10-20% is needed.

Bud opening

Use of germicides, sucrose and hormonal solution to promote the opening of immature buds in crops like chrysanthemums, rose, carnation, gladiolus, snapdragon, etc.

Grading, bunching and packaging

After harvesting the flowers should be graded according to various grades as per specification for local and distant market. Then these should be pulsed and made into bunches of 5, 10, 20, 50, 100. Cut flower should be packed in corrugated cardboard boxed or sleeves. Packaging must ensure protection of flowers against physical damage and for this cotton or news paper can be used as cushion material.

Storage

After pre-cooling and pulsing the flowers can be stored at low temperature i.e. in cold store to regulate the flower market or to avoid the glut in the market. Controlled atmospheric (CA) modified atmospheric (MA) or hypobaric (LP) storage method can be used to enhance the post harvest life of flower.

Recommended temperature and RH conditions for flowers storage

Name of commodity	Temp (^{o}C)	RH (%)	Approximate Shelf-Life
Alstroemeria	1	90-95	1 week
Anthurium	13	80	1 week
Asparagus	0-1	95-100	7-10 days
Aster	0-1	90-95	1 week
Asiatic lily, Oriental Lily	0-1		
Baby's Breath, Gypsophila	0-1	90	3 week
Bird-of-Paradise	8	85-90	14 days
Carnation	1	90-95	2-4 weeks
Chrysanthemum	0.5-2	85-90	12-15 days
Crossandra	15-20		
Daffodil	0-1	90	2 weeks
Delphinium, Larkspur	0-1	90-95	7 days
Freesia	0-1	90-95	2 weeks
Gladiolus	7	90-95	7-15 days
Gerbera	2-4	90-95	1week
Leatherleaf Fern	1-6		2 weeks
Iris	0	90-95	1 week

Marguerite Daisy, Boston Daisy	0-1	90-95	3-7 days
Marigold	8-12	90-95	1 - 2 weeks
Rose	0.5-2	90-98	7-10days
Snapdragon	0-1		10 days
Statice	0-1	90-95	6 weeks
Stock	0-1	90-95	3-5 days
Sunflower	0-1		
Sweet Pea	0-1		1 week
Sweet William	2-3		
Orchid	5-7		2 weeks
Torch Ginger	12.5-15		10-17 days
Tuberose	7-10	80 – 90 %	5-10-days
Tulip	1	85	7 week

Transport

Flower should be transported in corrugated cardboard boxes. The flowers which are sensitive to ethylene, ethylene scrubbers containing $KMnO_4$ should be added to those boxes. Some of the flowers are like gladiolus and snapdragon are sensitive to geotropic bending, so these should be transported in upright position. Some of the flower crops show yellowing during transportation due to lack of light, therefore there should bwe a provision of light inside the transporting vehicle.

Fresh flower preservatives

Fresh flower preservatives are chemicals added to water to make flowers last longer. They contain a germicide, a food source, a pH adjuster, water, and sometimes surfactants and hormones. Germicides are used to control bacteria, yeasts and molds. These microorganisms harm flowers by producing ethylene, blocking the xylem, producing toxins and increasing sensitivity to low temperatures. Bacterial counts of 10 to 100 million per 1 milliliter impairs uptake, while counts of 3 billion per 1 milliliter causes wilting. Some common germicides are listed in table:

Germicide Types	Common Name	Recommended Concentration
8-hydroxyquinoline sulphate	8-HQS	200–600 ppm
8-hydroxyquinoline citrate	8-HQC	200–600 ppm
Silver Nitrate	AgNO3	10–200 ppm
Silver Thiosulfate	STS	0.2–4 ppm
Thiobendazole	TBZ	5–300 ppm
Quarternary ammonium salts	QAS	5–300 ppm
Slow-release chlorine compounds	50–400 ppm of Cl	
Aluminum sulphate	Al2(SO4)3	200–300 ppm

8-HQC is the most common one used in commercial floral preservatives. Sucrose is the most common food source used in floral preservatives. It provides energy to sustain flowers longer and to open flowers in the bud stage. 1 to 2 percent sucrose is the standard amount in preservatives. Never use sucrose without a germicide, as it is the primary food source for microorganisms, too. Acids or acid salts are added to adjust the pH of the water to 3.5 to 5.0. At this pH, less microbes can grow and water is taken up by the flowers more easily. Surfactants and wetting agents reduce water tension so water is taken up more easily, also. Tween 20 and Triton are examples of surfactants.

Commercial Fresh Cut Flower Preservative

- Floralife
- Rogard/Silgard
- Chrystal
- Prolong
- Oasis
- Vita Flora

Holding

After pulsing and storage flowers are held in a solution containing sucrose, germicide ethylene inhibitor and growth regulator, that type of solution is called preservative or vase solution. The flowers can be kept in holding solution either at wholesaler, retailer or consumer level. Basically, the concentration is much lower than pulse solution. The anti-microbial agents like 8-HQC (8-hydroxy quinoline citrate), 8-HQS (8- hydroxy quinoline synthesis), aluminium sulphate, anti-ethylene agents like STS (Silver thiosulphate), $AgNO_3$ and acidifuing agents like citric acid are widely used as vase solution. Even plant growth regulaters like gibberellic acid, benzyl adenine, are also reported to improve vase life and quality of gladiolus and chrysanthemum. Growth retardants like CCC (cycocel), SADH (Succinic acid dimethyl hydraride) and MH (malic hydrazide) have also been reported to improve vase life of some cut flowers. Ethylene inhibitor like Amino ethoxy vinyl glycine (AVG), Methoxy vinyl glycine (MVG) and Amino oxyacetic acid (AOA) are beneficial in ethylene sensitive flower. Recently, chemicals like 1-MCP (1-methyl cyclopropene) and 1-OCP (1-octacalcium phosphate) have been found to be highly effective especially for ethylene insensitive flowers.

POST-HARVEST MANAGEMENT OF CEREAL CROPS

Each type of cereal requires a specific post-harvest treatment, however, there are certain general principles that apply to most of them.

Cereals undergo a number of processing stages between harvest and consumption. This chain of processes is often referred to as the total post-harvest system. The post-harvest system can be split into three distinct areas.

The first is the preparation of harvested grain for storage. The second, which is referred to as primary processing, involves further treatment of the grain to clean it, remove the husk or reduce the size. The products from primary processing are still not consumable.

The third stage (secondary processing) transforms the grains into edible products.

Primary processing involves several different processes, designed to clean, sort and remove the inedible fractions from the grains.

Primary processing of cereals includes cleaning, grading, hulling, milling, pounding, grinding, tempering, parboiling, soaking, drying, sieving.

Secondary processing of cereals (or 'adding value' to cereals) is the utilisation of the primary products (whole grains, flakes or flour) to make more interesting products and add variety to the diet. Secondary processing of cereals includes the following processes: fermentation, baking, puffing, flaking, frying and extrusion.

1. **Puffing:-** Puffed grains are often used as breakfast cereals or as snack food. During puffing, grains are exposed to a very high steam pressure which causes the grain to burst open. The puffed grains can be further processed by toasting, coating or mixing with other ingredients.
2. **Flaking:-** Flaked cereals are partially cooked and can be used as quick-cooking or ready to eat foods. The grains are softened by partially cooking in steam. They are then pressed or rolled into flakes which are dried. The flakes are eaten crisp and should have a moisture content of below 7%.
3. **Fermentation:-** Doughs made from cereal flour can be fermented to make a range of products.
4. **Baking:-** Doughs and batters made from cereal flours are baked to produce a range of goods.
5. **Extrusion:-** Extrusion involves heating and forcing food (usually a dough) through a small hole to make strands or other shapes. The extruded shapes then undergo further processing such as frying, boiling or drying. Extruded products include pastas, noodles, snack foods and breakfast cereals.

- **The Post-Harvest Cereal System**

Post-harvest treatment for storage

a. **Harvesting:-** There is an optimum time for harvesting cereals, depending on the maturity of the crop and the climatic conditions. This has a significant effect on the quality of the grain during storage.

Harvesting often begins before the grain is ripe and continues until mould and insect damage are prevalent. Grain not fully ripened contains a higher proportion of moisture and will deteriorate more quickly than mature grains because the enzyme systems are still active.

If the grain remains in the field after maturing, it may spoil through wetting caused by morning dew and rain showers. There is also an increased risk of insect damage.

Cereals are traditionally harvested manually.There are three main types of harvesting equipment for the small scale producer: manual, animal powered and engine powered.

A range of mechanised harvesting equipment suitable for the small-scale farmer has been developed. Some of it is more efficient and cost effective than others.

Harvested crops are left in the field for a few days to dry before further processing.

b. Threshing:- Threshing is the removal of grains from the rest of the plant. It involves three different operations: Separating the grain from the panicle; sorting the grain from the straw; winnowing the chaff from the grain.

Separation of the grain from the panicle is the most energy-demanding of the three processes. It is the first process to have been mechanised. Sorting the grain from the straw is relatively easy, but is difficult to mechanise. Winnowing is relatively easy, both by hand and by machine.

Most manual threshing methods use an implement to separate the grain from the ears and straw. The simplest method is a stick or hinged flail that is used to beat the crop while it is spread on the floor.

A range of engine powered threshers are available.

c. Winnowing:- Winnowing is the separation of the grains from the chaff or straw. It is traditionally carried out by lifting and tossing the threshed material so that the lighter chaff and straw get blown to one side while the heavier seeds fall down vertically.

Hand-held winnowing baskets are used to shake the seeds to separate out the dirt and chaff. They are very effective, but slow.

There is a range of winnowing machines that use a fan to create artificial wind. This speeds up the winnowing process.

Some of these contains sieves and screens that grade the grains as well.

d. Drying:- Prior to storage or further processing, cereal grains need to be dried. The most cost-effective method is to spread out in the sun to dry. In humid climates it may be necessary to use an artificial dryer.

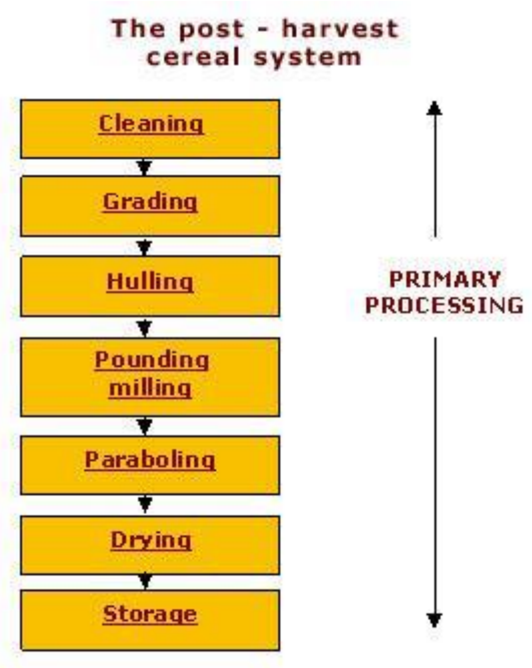
Simple grain dryers can be made from a large rectangular box or tray with a perforated base. The grain is spread over the base of the box and hot air is blown up through a lower chamber by a fan.

The fan can be powered by diesel or electricity and the heat supplied by kerosene, electricity, gas or burning biomass.

Cereal grains should be dried to 10-15% moisture before storage.

e. Storage:- Dried grains are stored in bulk until required for processing. The grains should be inspected regularly for signs of spoilage and the moisture content tested. If the grain has picked up moisture it should be re-dried. Grains are often protected with insecticides and must be stored in rodent-proof containers.

Primary processing



a. **Cleaning and Grading:-** Before further processing, grains are cleaned and graded according to size. Winnowing machines can be used to separate out the chaff, soil and dirt. Some machines have integral sieves that combine cleaning with grading.

b. **Hulling:-** Several grains have an unpalatable husk or shell that needs to be removed by a decorticator. A range of specialised machines are available for this task. A range of small rice hullers (both manual and powered) is available. Less rice is broken during hulling if the rice is parboiled first. Rice polishers are available for removing the rice bran after hulling.

c. **Pounding/Milling:-** Three main types of grain mill are available: Plate mill; Hammer mill; Roller mill. The choice of mill depends on the raw material and the scale of production. Hammer mills are almost universally used throughout the developing world. Roller mills are not used at the small scale because of their high cost and maintenance requirements.

The plate mill is usually limited to about 7kW and is derived from the stone mill or quern. Two chilled iron plates are mounted on a horizontal axis so that one of the plates rotates and the grain is ground between them. The pressure between the two plates governs the fineness of the product and is adjusted by a hand screw.There are manual versions of the plate mill available, though they are arduous and hard work to use.

Small-scale hammer mills range in size from 2kW to 20kW. They consist of a circular chamber in which beaters whirl at a high speed. The milled grain is filtered out through a perforated plate that runs around the edge of the mill chamber. The size of the holes in the perforated plate determines the fineness of grinding of the particles. Most grains can be ground in a hammer mill. Grain for human food is ground to a 1mm particle size while animal food is ground to a 3mm particle size.

Hammer mills cannot be used for wet milling. Roller mills crush the grains rather than milling them into smaller particles. Roller mills are usually used for animal food. It is important to ensure that the grains have the optimum moisture content before milling. If the grain is too dry and hard, it is difficult to break down and requires more energy to convert it into flour. If the grain is too moist, the material sticks to the mill. The optimum moisture content varies between cereal types and with the particular mill being used. Dry grain can be conditioned by soaking in water. Moist grain can be dried before grinding. Different cereal grains have different milling and grinding requirements.

d. **Paraboiling:-** Parboiling rice is an optional step, but one that improves the quality of hulling as it results in fewer broken grains. About 50% of all rice grown is parboiled.

Parboiling involves soaking and heating the rice which pre-cooks the grains, loosens the hull, sterilises and preserves the rice.At the village level, parboiling is carried out in large pans over an open fire. Rice parboilers, that improve the efficiency of cooking, are available.

e. Drying:- Prior to storage or further processing, cereal grains need to be dried. The most cost-effective method is to spread out in the sun to dry. In humid climates it may be necessary to use an artificial dryer.

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f. Storage- Dried grains are stored in bulk until required for processing. The grains should be inspected regularly for signs of spoilage and the moisture content tested. If the grain has picked up moisture it should be re-dried. Grains are often protected with insecticides and must be stored in rodent-proof containers.

SECONDARY PROCESSING

Raw materials: - The quality of raw materials has an influence over the quality of the products. High quality raw materials should be used.

Small-scale bakers do not normally have facilities for flour analysis and rely on information supplied by the miller or wholesaler. There are a few simple tests that they can carry out which give useful information about the flour quality.

a. Flour:- Flour can be milled from a variety of cereals. The type available in each country or region may depend upon the types of cereal grown, although wheat flour tends to be available in most places.

1. Wheat flour:- Wheat flour contains proteins known as glutens. These are capable of forming a strong elastic network within the dough, which is very useful when making leavened bread.

The protein network traps the gas that is given off by the yeast during fermentation. This causes the dough to increase in volume and produces a bread with a light texture.

If flours that are low in gluten are used to make leavened bread, the gas escapes and the bread is flat and heavy.

Wheat flour is available in different grades according to the degree it is extracted from the whole wheat grain. Flours of different extraction rates include the following:

- Wholemeal flour - 100% extraction
- Wheatmeal flour - 90-95% extraction
- Straight run flour - 70-72% extraction
- Patents - 20-40% extraction

2. **Non-wheat flours:-** There are a variety of non-wheat flours available that can be mixed with wheat flour to make bread.
   - **Cassava flour** is a fine white powdery flour that has a shelf life of up to one year. It is widely used as a staple food and for the production of a range of fried and baked goods including bread, cakes and biscuits.
   - **Cereal flours**, especially from maize and sorghum, which are both staple crops, are used to make breads and snackfoods. Sorghum is mainly used to make bread or porridge. Maize is used to make tortillas, snacks and for the production of cornflour and thickeners.
   - **Soy/composite flour** is a fine creamy flour that is combined with maize flour or other cereal flours to increase the protein content and balance the amino acid composition of the composite flours. In this form it is used as a breakfast porridge and as a weaning food.

Different types of wheat flour -

Different types of wheat flour are available in each country. Wholemeal flour is used for the production of brown bread, rolls and other high fibre products.

- Atta is a wheat flour that is suitable for making chappatis. It is also available as a wheatmeal flour.
- Special bakers flour (bread making flour) is a strong flour that is used for bread, rolls and pastry. Bakers flour should contain a good quality gluten so that it can produce a light bread.
- Biscuit flour. This is a special blend of flour that is made for mechanical biscuit plants.
- Self-raising flour. This flour is a soft flour that is fortified with a chemical aerating additive similar to baking powder. It is used for making chemically aerated breads such as soda bread. Soft flour is used for cake making.

Cereal	**Crude protein**	**Crude fat**	**Ash**	**Crude fibre**	**Available carbohydrate**
Brown rice	7,3	2,2	1,4	0,8	64,3
Sorghum	8,3	3,9	2,6	4,1	62,9
Rye	8,7	1,5	1,8	2,2	7108
Oats	9,3	5,9	2,3	2,3	62,9
Maize	9,8	4,9	1,4	2,0	63,6
Wheat	10,6	1,9	1,4	1,0	69,7
Barley	11,0	3,4	1,9	3,7	55,8
Pearl mil	11,5	4,7	1,5	1,5	63,4

Maize

Maize can either be wet or dry milled. In dry milling, maize is ground between stones or by using a hand-powered plate mill or at a larger scale, using a hammer mill or powered plate mill.

In wet milling, the grain is soaked and allowed to ferment slightly to improve the flavour before milling with a hand or pwered plate mill.

Maize is sometimes soaked in alkaline water to facilitate removal of the bran before it is milled. If the maize meal is not used whole, it is transferred to a flat basket and shaken so that the bran is separated from the floury endosperm.

The flour is sometimes ground again to make a finer product. The bran is often used to feed chickens.

Maize has a relatively high fat content and tends to go rancid quickly. Ground maize meal therefore has a short shelf life.

Paddy rice

In some countries paddy is parboiled before the husk is removed. Parboiling is the partial cooking of the rice to gelatinise the starch, which makes the grain tougher. There is also a slight change in flavour which some people prefer.

The toughening process makes the seed more resistant to insect attack and to shattering during husking. It also helps to prevent absorption of moisture from the air during storage. The parboiling process involves three stages:

(i) Soaking or steeping of the paddy in cold or hot water to increase its moisture content

(ii) Steaming to gelatinise the starch in the kerneldrying.

The rice should be dried carefully after parboiling to minimise losses. Husking paddy, which is sometimes referred to as de-husking or milling is the process of removing the outer husk.

Husked paddy is referred to as brown rice, whereas de-husked (or polished) rice is white rice. Brown rice is nutritionally superior to white rice as it contains some of the bran which contains protein and vitamin B1 (thiamine).

Millet

The outer layers of some varieties of sorghum seed (usually the red seed varieties) contain tannins that are slightly toxic, have a bitter taste and inhibit the digestion of proteins. For this reason, sorghum is generally hulled before grinding into a flour.

Traditionally sorghum and millet is ground by hand using querns or hand plate mills.

The seed is winnowed to remove foreign matter, then put into a large mortar and wetted. It is then pounded to strip the bran or shell from the grain, followed by winnowing to get rid of the bran, Pounding and winnowing are repeated several times to get a good quaity milled seed.

The milled seed is washed to remove any small pieces of bran and soaked in water for 24 hours to condition or temper it. The grain is dried to the correct moisture content then re-ground using a pestle and mortar.

2 IMPORTANT GOVERNMENT SCHEME FOR FOOD SECTOR

1. **Scheme for Infrastructure Development:-** To fulfil the need for creation of integrated and holistic infrastructure for food processing sector, Ministry of Food Processing Industries (MOFPI) had launched new Schemes in 11th FYP with strong focus on creation of modern enabling infrastructure to facilitate growth of food processing and creation of an integrated cold chain mechanism for handling perishable produce. Under the initiatives of MOFPI for strengthening infrastructure in agro and food processing sector, it had launched the Mega Food Parks Scheme, Scheme for Cold Chain, Value Addition and Preservation Infrastructure and Scheme for Modernization of Abattoirs in the 11th Five Year Plan.
2. **Mega Food Parks Scheme:-** The Mega Food Parks Scheme (MFPS) is the flagship program of the Ministry of Food Processing Industries (MFPI) during the 11th five year plan. The scheme aims to accelerate the growth of food processing industry in the country through facilitating establishment of strong food processing infrastructure backed by an efficient supply chain.

   The Mega Food Parks Scheme provides for a capital grant of 50 percent of the project cost in difficult and ITDP notified areas (with a ceiling of Rs 50 crores). The grant shall be utilized towards creation of common infrastructure in CPC and PPCs in the park. Such facilities are expected to complement the processing activities of the units proposed to be set up at the CPC in the Park. Each Mega Food Park may take about 30-36 months to be completed.

   Out of 30 Mega Food Parks proposed during the 11th five year plan, the Ministry has taken up 15 projects under the Scheme so far. Of this, Final approval has been accorded to 8 Mega Food Parks in the States of Andhra Pradesh, Punjab, Jharkhand, Assam, West Bengal, Uttarakhand, Tamil Nadu and Karnataka. The cumulative project cost of these 8 Parks is Rs. 930 crore which includes total grant assistance of Rs.500 crore under the Scheme. In-principle approval has been accorded to remaining 7 projects. In addition to these, 15 new Mega Food Parks are in the process of Government approval.

3. **Scheme for Cold Chain, Value Addition and Preservation Infrastructure**

   The Task Force on Cold Chain set up by the Ministry of Agriculture has identified a huge gap of 9 to 10 million tonnes of cold storage capacity in the country.

   Ministry of Food Processing Industries through its Scheme for Cold Chain, Value Addition and Preservation Infrastructure has been successfully addressing the above issue. The Scheme was approved in 2008 with an objective to provide integrated and complete cold chain, value addition and preservation infrastructure facilities without any break, for perishables from the farm gate to the consumer. The assistance under the Scheme includes financial assistance (grant-in-aid) of 50% the total cost of plant and machinery and technical civil works in General areas and 75% for NE region and difficult areas subject to a maximum of Rs 10 crore.

In the first phase, the Ministry has approved 10 integrated cold chain projects in 2008-09, which are already being implemented in different parts of the country. Out of the 10 projects, 8 have started commercial operation. Substantive value addition, reduction in wastage and enhancement in farmers' income is evident from concurrent evaluation of the projects.

In the 2nd phase, 39 projects have been approved. The approved projects envisage a total investment of about Rs. 850 crore which would be creating cold chain capacity of about 1.60 lakh MT.

Taking note of the high demand and the gap in the requirement of cold storage, processing, preservation and cold logistics facilities in India, the Ministry is planning to upscale the Scheme and Planning Commission has already accorded 'In-principle' approval for the same.

Modernization of abattoirs

Ministry has approved 10 projects in 1st phase which are at various stages of progress. Two projects have been completed. A proposal for up-scaling the scheme is under consideration.

4. **Scheme for Technology Upgradation/Establishment/ Modernization of Food Processing Industries.**

Under the Scheme for Technology Upgradation/ Establishment/ Modernization of Food Processing Industries, financial assistance is provided in the form of grants-in-aid for setting up of new food processing units as well as Technological Upgradation and Expansion of existing units in the country. Ministry extends financial assistance in the form of grant-in-aid to entrepreneurs @ 25% of the cost of Plant & Machinery and Technical Civil Works subject to a maximum of Rs. 50 lakhs in general areas or 33.33% subject to a maximum of Rs. 75 lakhs in difficult areas.

The implementation process of the Scheme has been made more transparent and decentralized from 2007 onwards.

Earlier all the applications for such grants were received by the Ministry through the State Nodal Agencies. These applications were then centrally processed and grants disbursed directly by the Ministry. From 2007-08, the receipt of applications, their appraisal, calculation of grant eligibility as well as disbursement of funds has been completely decentralized. Under the new procedure, an entrepreneur/applicant can file application with the neighborhood Bank branch/Financial Intuition (FI). The Bank/FIs would then appraise the application and calculate the eligible grant amount as per the detailed guideline given to them by the Ministry. The Banks/ FIs appraise project and its recommendation for the release of grant is transmitted to the Ministry through e-portal established for this purpose. After the recommendation and requisite documents are received from the Bank/FIs, the Ministry sanctions the grant and transfer the funds through the e-portal itself. This has resulted in faster sanction procedure and enlarged outreach of the Scheme.

In the 11th Five Year Plan a total allocation of Rs. 600 crores was provided. Out of total allocation, an amount of Rs 488.51 crore has been received so far including Rs.98 crore BE of 2011-12. Ministry has utilized almost the entire budget allocated under this scheme (except NER) and has assisted 2532 Food Processing Units so far. Ministry has taken initiatives to create awareness in the industry/entrepreneurs by advertisements, organizing investors meet and special meetings in NER. In so far as general areas are concerned, the Ministry has been continuously reviewing the status and organizing meetings with the focal point banks on a quarterly basis. Ministry has also engaged an agency (CMI) to maintain the data and to monitor the scheme closely. Under this arrangement, the details of all the pending applications along with their present status has been put in the public domain on the website of the Ministry. Any applicant can find out current status of his application by clicking on to "http://www.mofpi@nic.in" e-portal-status of applications OR "http://cmi/mofpi/status".

This scheme has added huge processing capacity to the food processing industry which in turn has resulted in significant reduction of wastages.

5. **Quality Assurance, Codex Standards and Research & Development and Promotional Activities**

In today's global market quality and food safety gives a competitive edge for the enterprises producing processed foods and providing services. Apart from domestic standards for food products, processes and management practices, Codex prescribes international standards for safety and quality of food as well as codes of good manufacturing practices, which are accepted worldwide. Further, equal emphasis is required to be accorded to R&D activities for development of innovative products, cost effective processes and efficient technologies for food processing sectors. The scheme for food safety, codex and R&D has been successful in making a dent in this area in the country. The scheme comprises of following components.

(i) Setting up/Upgradation of Food Testing Laboratories (maximum grant Rs. 2.50 crore per project). (22 projects assisted in XI Plan so far)
(ii) Implementation of HACCP / ISO / GMP / GHP / Safety Management System in food processing units (maximum grant Rs. 15.00 lakh / Rs. 20.00 lakh per project in general area / difficult area). (18 Projects assisted in XI Plan so far).
(iii) Research & Development in food processing sector. (40 projects assisted in XI Plan so far)
(iv) Promotional activities including advertisement & publicity. (Rs. 46.78 crore spent in XI Plan so far)

6. **Human Resource Development:**

The Food Processing Industry is critical to India's development as it establishes a vital linkage and synergy between the two pillars of the economy –Industry and Agriculture. Demand for trained manpower including entrepreneurs, managers, technologists, skilled workers to cater to the growing needs of the food processing industry is increasing day-by-day. Besides latest technology & diversification and new ways of managing and marketing is required by the existing food processing industry to face global competition.

(i) Creation of infrastructural facilities for running degree/ diploma courses in food processing (maximum grant Rs. 75.00 lakh per project). (33 projects approved in XI Plan so far)

(ii) Entrepreneurship Development Programmes (EDP) (maximum grant Rs. 2.00 lakh per programme). 846 EDPs assisted during 11th Plan so far.

(iii) Setting up of Food Processing Training Centres (FPTC) (maximum grant Rs. 6.00 lakh / Rs. 15.00 lakh per project for single line/multi line products). (140 Centres assisted in XI Plan so far)

(iv) Training at recognized national / state level institutes etc. sponsored by MFPI or other training programme.

During 11th Five Year Plan, the Ministry is expected to provide assistance for setting up of about 270 FPTCs, organize 750 EDPs and facilitating need based professional development training programmes. In addition about 55 Universities/Colleges/ Institutions would be assisted for creating infrastructure facilities for degree/diploma courses in food processing.

Strengthening of Institutions

7. **Indian Institute of Crop Processing Technology - A National Institute with International Repute**

Indian Institute of Crop Processing Technology is a world class R&D and Educational Institute under the Ministry of Food Processing Industries, Government of India. The mandatory activities of IICPT are teaching, research and outreach activities in post harvest processing, preservation and value addition of agricultural and horticultural produces. IICPT and its scientists are experts in their own fields of research. IICPT has created in its main campus at Thanjavur world class research laboratories for conducting research in different areas of food processing technologies.

IICPT focuses research in major theme areas to address problems like: development of indigenous technology knowledge based food, composite grains foods, energy saving in parboiling, improving milling techniques of cereal grains, pulses, oil seeds and millets, food processing effluent treatment, creating ready to use dry mix fermented batter for idly and other Indian foods, new food product development based on grains, fruits and vegetables, fortification of processed foods for making health foods at affordable prices, development of new equipments for puffing, multipurpose yard drying, parboiling, for producing hand pound rice, reducing storage losses, economic utilization of biomass, food industries by-product and waste utilization.

To encourage new entrepreneurs to participate in the business of food processing and value addition, they have to be technically trained by providing hands-on experiences. They need to see and work for themselves on processing and value addition of foods. To fulfill all the basic needs, IICPT has created a Hi-tech, state of the art food processing incubation cum training center in its campus with the different product lines. It has also been offering consultancy services for the industry.

Considering the necessity for the growth of food processing sector and food processing industries and the future demands for trained manpower in the areas of food processing, the Institute began offering formal degree courses at bachelors, masters and doctoral levels in food process engineering from 2009 – 10 academic year.

Some of the major achievements of IICPT in the last four years have been as under:-

(i) Filed 11 patents and got 4 patents approved.
(ii) Developed Mobile Processing Unit for Tomatoes.
(iii) Conducts approx 320 one day outreach programme for farmers all over the country.
(iv) Developed 10 new products and done their commercial testing.
(v) Established a Food Testing Lab of International Standards at Thanjavur.

8. **National Meat and Poultry Processing Board**

The Government of India established the National Meat and Poultry Processing Board on 19th Feb 2009.

The Board is an autonomous body and would initially be funded by the Government of India for 3 years and would be managed by the industry itself. The Board has 19 Members including CEO of the Board. The Chairman is from the industry.

This industry driven institution has been launched to work as a National hub for addressing all key issues related to Meat and Poultry processing sector for the systematic and proper development of this sector. The Board serves as a single window service provider for producers/manufacturers and exporters of meat and meat products, for promoting the meat industry as a whole and it would result in large number of employment opportunities.

Some of the major achievements of the Board in last two and half years are:

(i) Establishing a world class Meat Products testing lab.
(ii) Conducting nearly 40 one day training progammes every year for meat workers (Butchers) all over the country.
(iii) Developing a model for a modern meat shop.
(iv) Arranging two National Conferences and five experts meet.

9. **Indian Grape Processing Board**

The Union Government in 2009 gave its approval for the establishment of the Indian Grape Processing Board (IGPB) at Pune, Maharashtra which is close to the principal grape growing/processing areas in the country. The 15 member Board that is led by an eminent professional from the Industry has been registered under the Societies Registration Act, 1860 at Pune.

- The important functions and objectives of the Board are as under:
- To focus on Research & Development, Extension, and Quality up gradation, market research and information, domestic and international promotion of Indian wine.

- To foster sustainable development of Indian Wine Industry
- To formulate a vision and action plan for the growth of Indian Wine Sector including research and development for quality upgradation in new technologies/processes.

During the two years of its existence, the Board has focused on the promotion of "Wines of India" in the domestic as well as international market by participating in important and relevant exhibitions/fairs, consumer awareness & training programmes, undertaking advocacy work with the various State Governments/ Central Ministries on various issues related to taxes/levies and promotion aspects.

10. **National Institute of Food Technology, Entrepreneurship & Management (NIFTEM)**

The Government in 2006 approved setting up of NIFTEM at an estimated cost of Rs. 244.60 crore including foreign exchange component of US $ 8.1 million. Further, Government in April, 2011 approved revision of the estimated cost for setting up of NIFTEM from Rs. 244.60 cr to Rs. 479.94 cr.

Since the legal status of NIFTEM as a Company was creating hurdles in obtaining statutory recognition as a Deemed University from UGC for running its Academic courses, the government has approved:

- Registering NIFTEM as a Society.
- Transfer all assets & liabilities from the Company to the Society
- Winding up of NIFTEM Company.

In pursuance of above decision NIFTEM Society has been incorporated on 19.05.2010. Its Assets & Liabilities have been transferred from the Company to the Society w.e.f 11.11.2010. The winding up process of the Company has been initiated.

NIFTEM's Mandate

NIFTEM would work as ―Sector Promotion Organisation/ Business Promotion Organisation of the food processing sector. The other major objectives of NIFTEM are:

- Working as a ―One Stop Solution Provider to all the problems of the sector.
- Working for ―Skill Development and Entrepreneurship Development for the sector.
- Facilitating business incubation services with its ultra modern pilot plant for processing of fruits and vegetables, dairy, meat and grain processing.
- Conducting Frontier Area Research for development of the Sector.
- Developing world class managerial talent with advanced knowhow in food science and technology.
- Providing intellectual backing for regulations which will govern food safety and quality and at the same time foster innovation.

- Functioning as a knowledge repository on various aspects of food processing such as product information, production and processing technology, market trends, safety and quality standards, management practices among others.
- Working for upgradation of SME food processing clusters.
- Facilitating business incubation services with its ultra modern pilot plans for fruit and vegetables, dairy, meat and grain processing.
- Promoting cooperation and networking among existing institutions within India and as well as with international bodies.

Construction of the campus, recruitment of faculty and other steps to make the Institute fully functional from the next year are being taken.

Skill Development: Short term Training Programmes

NIFTEM started its activities under Skill Development by conducting the short term training programmes from 20th -22nd July'2011 and 19th -21st September, 2011.

Outreach programmes: NIFTEM has also been conducting nearly 20 outreach progammes every year all over the country with the help of its knowledge partners.

UNIT IV. Food Processing and Value Addition

1. Principals and Methods of Preservation of Fruits and Vegetables

Preservation means just protect the foods against the spoilage, but scientifically it may be defined as a science which deals with the process for prevention of decay or spoilage of the food is called preservation.

In other words, just controlling the physical, chemical or microbial changes in the foods is called preservation.

1. Physical Changes: Colour, flavour, texture and taste *etc.*

2. Chemical Changes: Carbohydrate, fats, proteins, vitamins and minerals.

3. Microbial Changes: Mould, yeasts and bacteria

Why do preserve the food?

1. To supply to increase the shelf life of the food for increasing the supply.
2. To make the seasonal fruits available throughout the year.
3. To add the variety to the diet.
4. To save time by reducing preparation, time and energy by fire.
5. To stabilize the prices of the food in the market.
6. To improve the health of the population.

Principles of Preservation: There are three main principles:

A. Prevention / delay the microbial decomposition of the food.
B. Prevention / delay the shelf decomposition of the food.
C. Prevention of damage by insects, animals, mechanical causes *etc.*

A. Prevention / delay the microbial decomposition of the food

1. By keeping out the micro organisms -Asepsis
2. By Removal of micro organisms -Filtration
3. By Hindering the growth and activity of micro organisms -Anaerobic condition
4. By killing the micro organisms -Exposing at high temperature

1. Asepsis: It means preventing the entry of micro organisms by maintaining of general cleanliness, while picking, grading, packing and transporting of fruits and vegetables, increase their keeping quality and the product prepared from them will be superior quality.

2. Filtration: Fruits juice, bear, soft drinks, wines *etc.* enter through bacteria proof filters which are made of Asbestos pad or unglazed porcelain type of materials. These filters contain the micro organisms and allow the water or juice to percolate though with or without pressure.

3. Anaerobic conditions: It can be maintained by:

(i) Replacing the O_2 by CO_2 carbonation

(ii) Evacuating the sealed container (fruit juice)

(iii) Use of oils from top of the food (pickles)

4. Exposing at high temperature: Fruits can be exposed by high temperature such as:

(i) Canning: Food is exposing to a high temperature (> 100^0C) which prevents spoilage and inactivate the enzyme present in the food.

(ii) Irradiation: In case of irradiation, the food is exposed to the radiations to kill the micro organism by ionizing and non-ionizing radiation like α, β and gamma rays. Her, food is exposed to electromagnetic or ionizing radiation or various frequencies ranging from low frequency electromagnetic to high frequency *i.e.,* gamma rays which destroy the micro-organism present in the food.

B. Prevention/delay the shelf decomposition

(i) By destruction or inactivate the enzyme – Blanching.

(ii) Prevention / delay the non-enzymatic chemical reactions – Antioxident

Blanching

1. It is primary treatments which have to soften the tissues to facilitate packaging.
2. To preserve the original colour and flavour
3. To destroy the certain enzyme which are undersirable
4. Elimination of the air
5. Mostly for vegetables
6. Remove micro-organisms
7. Remove astringent taste and toxins

Anti-oxidant

Anti-oxidant are substances which are used to protect the food gamma deterioration caused by exposure to the air.

1. BHA – Butylactic Hydroxy Anisole Vegetable oils

   BHT – Butylactic Hydroxy Toluene
2. Gellales: Animal fat, Vegetalbe oil
3. Tocopherols: Animal fat
4. Ascorbic acid: Fruit juices, Citrus oil, Wine, Bears *etc.*
5. Lactic acid: Processed fruits and vegetables, canned fruits,
6. Phosphoric acid: Vegetable oils, Animal fat and cola drinks

Methods of preservation of fruit and vegetable

There are two main basic methods:

a. Bacteriostatic methods

b. Bactericidal methods

a. Bacteriostatic Methods

1. Drying of foods

2. Use of chemical preservatives

3. Use of food additive

4. Use of low temperature

b. Bactericidal Methods

1. Pasteurization
2. Cooking
3. Canning
4. Irradiation

a. Bacteriostatic Methods

In this method, the environmental conditions are change to prevent the growth of micro organisms, such conditions are called bacteriostic. These are:

1. Drying of Foods

Drying is just removal of moisture from the food to a certain level at which micro organisms cannot grow is called drying, it can be done by two methods:

(i) Application of heat

(a) Sun drying (b) Mechanical drying

(c) Vacuum drying (d) Freeze drying

(ii) Binding the moisture in the food

(a) Use of Sugar (b) Use of Salt

(i) Application of Heat

a) Sun Drying: Sun drying is the method in which food is directly exposed to sunlight. It is generally done in the places where plenty sunshine is available for long period e.g., Rajasthan. The dried product in this method is inferior in quality.

b) Mechanical drying: This is a method of drying where application of heat is applied by a mechanical dryer under the controlled conditions of temperature, humidity and air flow.

c) Vacuum drying: The temperature of the food and the rate of water removal are controlled by regulating the degree of vacuum and intensity of heat input.

d) Freeze drying: In this method, the food is dried by sublimation process, *i.e.*, just converting the food into ice without passing through the liquid form of water by means of vacuum plus heat applied in the drying chamber. In this method, product first frozen then water is removed by vacuum and application of heat which occurs simultaneously in same chamber.

(ii) Binding the Moisture

a) Use of Sugar: The use of high concentration of sugar bindup the moisture and make the food have a certain level of moisture at which micro organisms are not able to grow.

b) **Use of Salt:** The concentration of salt causes the high osmotic pressure and tie up the moisture which inhibit the growth of micro organisms. It dehydrates the food by drying out and tie up moisture as it dehydrate the micro organisms cells. Salt reduces the solubility of O_2

in the food by reducing the moisture. It interferes with the action of proteolytic enzyme. The effeteness of NaC1 is varied with the concentration of salt and temperature.

2. Use of Chemical Preservative

Chemical preservatives are substances which are added to food just to retard, inhibit or arrest the activity of micro organisms such as fermentation, pacification and decomposition of the food. Chemical preservatives are of two types:

Class-1 preservatives: Common salt, sugar, dextrose, spices, vinegar, ascorbic acid

Class-2 preservatives: Benzoic acid and its salt, SO_2 and the salts of sulphuric acid, nitrates, sorbic acid and its salts, propeonic acid and its salts, lactic acid and its salts.

Among the class-2 preservatives, only two chemical preservatives are used in fruits and vegetables Preservation:

(i) KMS

(1) It releases the SO2 and it is unstable.

(2) It is used for the fruit which have non water solvent pigment (colourless).

(3) It cannot be used in naturally coloured juices such as phalsa, jamun because they have the Anthocynin pigment.

(4) It cannot be used in the product which are packed in container because it acts on the tin containers and oil, Hydrogen Sulphide (H_2S) which has an unpleasant smell and also form a black compound with the base plate of containers.

(5) Best to control moulds than bacteria.

(6) 350 ppm KMS is mostly used in fruit juice products.

(ii) Sodium Benzoate

(1) It is salt of benzoic acid and soluble in water.

(2) It delays the fermentation in the juices.

(3) It is commonly used in the product which are having natural colour such as anthocynin pigment.

(4) It is more effective against the yeast.

(5) 750 ppm Sodium benzoate is mostly used in fruit juices, squashes and cordials.

3. Use of Food Additive

Food additives are substances or mixture of substances other than basic foodstuffs, which are present in the foods as reagent of any aspects of production, processing, storage, packaging *etc.* Food additives are:

(i) Sugar,
(ii) Salt,
(iii) Acids,
(iv) Spices

In case of sugar and salts, they exerts osmotic pressure by water is diffuses from the product through a semi-permeable membrane until the concentration reached equilibrium. They kills the micro organisms or do not allow them to multiplication.

(i) Sugar: The concentration of 68-70% is used for preparation of jam, jelly, marmalades *etc.* sugar act as a preservative by osmosis and not as a true poison for micro organisms. It absorbs most of the available water, so little water available for the growth of micro organisms.

(ii) Salt: the concentration of salt 15-20% is used for the preparation such as pickles. Salt inhibits enzymatic browning and discolouration and also acts as an anti-oxidant.

It exerts its preservative action by:

1. Causing high osmotic pressure resulting in the plasmolysis of microbial cells.

2. Dehydrating food and micro organisms by tying up the moisture.

3. Ionizing to yield the chloride ion which is harmful to micro organisms, and

4. Reducing the solubility of oxygen in water, sensitizing the cells against CO_2.

(iii) Acids:

1. Many processed foods and beverages need the addition of acids to impart their characteristic flavour and taste in the final product because an acid provides desired flavour and taste.

2. They adjust the sugar and acid ratio in the food.

3. Proper balance flavour of the food.

4. They are also playing the role for controlling the pectin-gel formation.

Main acids are the following

1. Acetic acid (Vinegar)

2. Citric acid (Lime juice)

3. Lactic acid (Lactose)

1. Acetic acid: it is commonly used for pickles, chutney, sauce and ketchup, just to inhibit the growth of micro organisms.

2. Citric acid: It is used for preparation of jam, jelly, squash, nectar *etc.* just to increase the acidity.

3. Lactic acid: It is used for the formation of curd from milk, raw flavour, specific to pickles

(iv) Spices:

(1) Spices are plant products which are used in flavouring the foods and beverages to enhance the food flavour, colour and palatability.

(2) They act as antibacterial and antifungal activity.

(3) They impart as colour agent.

4. Use of Low Temperature

Low temperature retards the microbial growth and enzyme reaction because it retards the chemical reactions. This is not a permanent method because some micro organisms can also grow at low temperature.

1. Cellar storage: (Above 15^0C)

2. Refrigerated storage: (0 to 5^0C)

3. Freezing storage: (-18 to -40^0C)

1. Cellar Storage: These are the underground room where surplus food can be stored for some time; only root crops such as potato, onion can be stored for a limited period.

2. Refrigeration: Fruits and vegetables can be stored for 2-7 days. Semi-perishable crops, such as potatoes, apples *etc.* can be stored, in the commercial cold storage with proper ventilation, automatic controlled temperature for one year.

3. Freezing: It tie up the moisture and increase the concentration of dissolved substances in the food. But, sometimes enzymes are active even below the 0^0C.

In this case before freezing, 'Blanching' is necessary for vegetable freezing.

B. Bactericidal Method

In this method, food material is exposed to higher temperature and high temperature helps to killing of the micro organisms due to coagulation of protein. It helps in inactivation of enzyme. Here moist heat is more effective than dry heat. At low pH high temperature is required than the high pH. High temperature can be employed by following methods:

(i) Pasteurization: Below 100^0C

(ii) Boiling/ Cooking: at 100^0C

(iii) Canning: Above 100^0C

(i) Pasteurization

There are three methods of pasteurization

a) Bottle or holding pasteurization

This method is commonly used for the preservation of fruit juices at home. The extracted juice is strained and filled in bottles, leaving sufficient head space for the expansion of the juice during heating. The bottles are then sealed air-tight and pasteurized.

b) Overflow method

Juice is heated to temperature of about 2.5^0C higher than the pasteurization temperature and then filled in hot sterilized bottles up to the brim, during filling and sealing the temperature of juice should not fall below the pasteurization temperature.

c) Flash pasteurization

The juice is heated rapidly to a temperature of about 5.5^0C higher than the pasteurization temperature and kept at this temperature for about a minute. This method commonly used for canning of natural orange juice, grape and apple juices. It is a mild heat treatment; by pasteurization milk is pasteurized by HTST at 72^0C for 15 sec. Fruit juices are pasteurized at such temperature and for such periods as would render them sterile, without impairing their flavour. Usually, the juices are pasteurized at about 85^0C for 25-30 min., according to the nature of the juice and the size of container. Acid fruit juices require lower temperature and less time for pasteurization than the less acid ones.

Juices can be pasteurized in two ways

(1) By heating the juice at a low temperature for a High time (LTHT) and

(2) By heating the juice at high temperature for a short time (HTST).

(ii) Boiling/Cooking

The primary objective of cooking is to produce a palatable food. Cooking results in:

1. Destruction or reduction of micro organisms and inactivation of undesirable enzymes.

2. Destruction of potential hazard in the foods which are present naturally through micro-organism.

3. Improvement of colour, flavour and texture of the food.

4. It improves the digestibility of food component.

5. Putting the temperature about 1000C. by this method, food can be preserved for 10-24 hours at low temperature.

(iii) Canning

Canning is done at or above 100^0C. In case of fruits which are acidic, they are canned at 100^0C, while in case of vegetable those are nonacidic, they are canned at above 100^0C. Here, high temperature can be obtained by using steam pressure; time is varying according to the type of foods. Due to anaerobic condition any survivable organism will not grow.

On the basis of Acid, foods are divided into four different groups:

1. Low Acid Foods (pH 5.3 and above): Peas, Corn, Lime beans, Meat, fish, Poultry and Milk.

2. Medium Acid Foods (pH 5.3-4.5): Spinach, Asparagus, Beets and Pumpkin.

3. Acid Foods (pH 4.5-3.7): Tomatoes, Pears and Pineapple, Sauce.

4. High Acid Foods (pH below 3.7): Berries and Sauer kraut, Pickle.

Other methods of Preservation

Preservation by filtration

In this method juices are clarified by settling or by using ordinary filters, and then passed through special filters which are capable of retaining yeasts and bacteria. Various types of germ-proof filters are used for this purpose.

Preservation by carbonation

Carbonation is the process of dissolving sufficient CO_2 in water or beverage so that the product when served gives off the gas as fine bubbles and has a characteristic taste, carbonation life of beverage. Fruit juice beverages are generally bottled with CO_2 content varying from 1-8 g/lit though carbon should be avoided as it destroys the flavour of the juice. The keeping quality of carbonated fruit beverages is enhanced by adding about 0.005% sodium benzoate. The level of carbonation is required according to the type of fruit juice and type of flavour.

Preservation by fermentation

This is one of the oldest methods of preservation. By this method the foods are preserved by the alcohol or organic acid formed by microbial action. The keeping quality of alcoholic beverages vinegars and fermented pickles depends on the presence of alcohol acetic acid and lactic acid respectively. Wines, beers, vinegar, fermented drinks, fermented pickles are prepared by these processes. Fermentation is carried out by using acetic acid, lactic acid and alcohol *etc.*

Preservation by Antibiotics

Certain metabolic products of micro-organisms which are found to have a germicidal effect those are:

Nissin: - is an antibiotic produced by *Streptococcus lactis* an organism found in milk, curd, cheese and other fermented milk products. It is non toxic and it is widely used in food industry especially for preservation of acid foods.

It is commonly used in canning of mushroom tomatoes and milk products. Nisin suppress the growth of spoilage organisms.

Subtilin: - an antibiotic obtained from *Bacillus subtilis* is used in preservation of asparagus, corn and peas.

Pimaricin: - an antifungal antibiotic used for treating fruits and fruit juices.

Preservation by irradiation

It is a process of preservation of food by exposing them to ionizing energy radiation which kills most of the spoilage causing organism and also inactivates the enzymes responsible for browning *etc.* This method prevents the sprouting in storage condition (onion, potato *etc.*).

The irradiation of food can be considered to be a method of "Cold sterilization". Irradiation measured in rads.

Point to Remember

- The oxicity of SO_2 is increased at hight temperature.
- SO_2 content in pure KMS is 57.7%.
- Commercial effect of KMS is due to H_2SO_4.
- Germicidal effect of KMS is due to H_2SO_3.
- Dehydration and drying is permanent method of preservation.
- Sterilization by Ultera-high temperature (UHT) is done at temperature of 149^oC for 2 second.
- In carbonated fruit juice beverages CO_2 content is 1-8g/liter.
- Cold process is also known as Ultrafiltration.

Importance and Scope of Fruit and Vegetable Preservation in India

Fruits and vegetables are an important supplement to the human diet as they provide the essential minerals, vitamins and fibre (roughage) required for maintaining health.

India with a great diversity in climatic conditions and soil types is ideal for growing a large variety of fruits and vegetables, both indigenous and introduced.

Most fruits and vegetables are seasonal and perishable in nature. In a good season there may be a glut but because of insufficient transport facilities, lack of good roads and poor availability of packaging materials, the surplus cannot be taken quickly enough to markets in urban areas.

Moreover the surplus often cannot be stored for sale in off-season because of inadequate local cold storage facilities. Thus, the cultivator do not get a good price for their produce.

Although, the R and D efforts on the development of post-harvest handling has helped in reducing the spoilage, considerable losses continue to occur.

Two approaches are possible for solving this problem.

(i) One is the creation/expansion of cold storage facilities in the fruit and vegetable producing regions, as also in the major urban consumption centres, to ensure supply of fruit and vegetable throughout year.

(ii) Another approach is to process the fruits and vegetable into various products which could be preserved for a long time and add value to the product.

With increasing in purchasing power of middle class, there is increasing demand for factory made jams, gullies, pickles.

In spite of all these, the fruit and vegetable preservation industry of present is able to utilise less than 2% of the total production for conversion into products like canned fruits, juices and their beverage squashes etc. as against 40% in developed countries. Thus there is considerable scope for expansion of the industry, which in turn would give a fillip to development of horticulture, specially in hilly areas and through export of value-added products, earn more foreign exchange.

India is one of the cheapest producer of horticultural produce. If the Government addresses some of the gaps in processing industry, Indian economy will get a boost up.

(i) Most of the varieties grown in India are not suitable for processing.

(ii) Seeds of processble varieties can be imported and multiplied using tissue culture technique.

(iii) Lowering sales tax on agriculture produce may help the industry to grow.

(v)In New Exim Policy of Union Government, setting of Agriculture Export Zones (AEZ) to identify each state's competitive advantage and to promote the cultivation and processing of fruit and vegetable accordingly.

2. Important Value Added Product of Fruits and Vegetables

Jam, Jelly and Marmalade

Jam is prepared by boiling the fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold fruit tissues in position. It should contain not less than 68 per cent soluble solids. Jam may be made from a single fruit (apple, strawberry, banana, pineapple etc.) or from combination of two or more fruits. Jam contains 0.5-0.6% acid and invert sugar should not be more than 40%.

Components of Jam

- **Fruit Pulp:-** 45%
- **TSS:-** 68%
- **Acidity:-** 0.5-0.6%
- **Water:-** 33-38%

Processing of Jam

1. **Selection of fruit:-** Fully ripe fruit should be harvested for Jam making. Jam is best fruit for Jam making. Pineapple, carrot, strawberry, banana, peach, pear also used for jam making.
2. **Washing/Cleaning of fruit:**- Fruit shoul be cleaned by clean water.
3. **Preparation of Fruit:-** Fruit should be peeled and remove of core material for Jam making.
4. **Blanching:**- Blanching is the heating of fruit or vegetables for a short time with either steam or water, and is an essential step before canning, drying or freezing of food.

   This heating process is not meant to cook the food but to inactivate substances that would otherwise adversely affect the nutrient content, colour, flavour or texture during subsequent processing and storage.
5. **Cooking with Sugar**:- Fruit pulp start cooking with 1/3 quantity with sugar. After some time add remaining sugar.
6. **Adding of Citric Acid**:- For enhancement of test citric acid should be added at 103^{o}C temperature.
7. **Judging of End-Point:-**
   a. **Sheet or Flake test:-**A small portion of jam is taken out during boiling, in a spoon or wooden ladle and cooled slightly, it is then allowed to drop. If the product falls off in the form of a sheet or flakes instead of flowing and a continuous stream or syrup, it means that the end-point has been reached and product is ready, boiling is continued till the sheet is positive.
   b. **Temperature:-** 105^{0}C.
   c. **TSS:-** 68-70%
   d. **Weight Test:**- If total weight of jam is 1.5 time is more than sugar weight, jam is prepared.
8. **Packing:-** Jam should be fill in glass jar.
9. **Storage:-** Jam should be stored at dry and cool place.

Important Point:-

- The jam should be containing 30-50% invert sugar.
- Crystallization of jam occurs due to the less than 30% invert sugar, it can be prevent by adding of corn syrup or glucose along with cane sugar.
- Sticky and gummy jam is due to high percentage of total soluble solid (more sugar). This problem can be solved by addition of pectin or citric acid or both.
- Premature setting is due to low total soluble solid and high pectin content in the jam and it can be prevent by adding more sugar.
- Surface graining and shrinkage is caused by evaporation of moisture during storage of jam, it can be avoid by storing in a cooling place.
- Jam should be stored at 80% humidity for avoid the mould growth.

Jelly

Jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin containing fruit extract with sufficient quantity of sugar and measured quantity of acid.

Character of Ideal Jelly:-

- A perfect jelly should be transparent, well set, but not too stiff and should have the original flavour of the fruit.
- It should be firm enough to retain a sharp edge but should be tender enough to resist the applied pressure.
- It should not be gummy, sticky or syrupy or have crystallized sugar.
  - ✓ Guava is most suitable fruit for jelly making.
  - ✓ Fruits rich in pectin and acid: Sure apple, grape, lemon, orange, jamun, goose berry, cranberry, etc.
  - ✓ Fruits rich in pectin low acid: Apple, unripe banana, guava, sour cherry, fig, pear, loquat, etc.
  - ✓ Fruits low in pectin rich acid: Sweet cherry, pineapple, rhubarb, etc.
  - ✓ Fruits low in pectin and acid: Apricot, peach, pomegranate, raspberry, strawberry, overripe fruits, etc.
  - ✓ Tartaric acid is best for jelly preparation.
  - ✓ Pectin is most important constitute of jelly, it is present in fruits form of calcium pectate are responsible for the firmness of fruits.

Components of Jelly

- **Fruit Juice:- 45%**
- **TSS:- 65%**
- **Pectin:-** 0.5-1.0%
- **Acid:-** 0.75%
- **Water:-** 33-38%
- **pH:-** 3.2.

Preparation of Jelly:-

1. **Selection of fruit:-** Fruit should be harvested at half-ripe stage for jelly making because maximum pectin content in fruit at half ripe stage. If fruits are ripe when pectin change in pectic acid.

   Guava, sour apple, plum, karonda, wood apple, loquat, papaya and goose-berry are generally used for preparation of jelly. Apricot, pineapple, strawberry, raspberry, etc. can be used but only after addition of pectin powder, because these fruits have low pectin content.
2. **Washing/Cleaning of fruit:-** Fruit shoul be cleaned by clean water.
3. **Blanching:-** Blanching is the heating of fruit or vegetables for a short time with either steam or water, and is an essential step before canning, drying or freezing of food.

   This heating process is not meant to cook the food but to inactivate substances that would otherwise adversely affect the nutrient content, colour, flavour or texture during subsequent processing and storage.
4. **Extraction of fruit juice:-** For jelly making juice is excreted after blanching.
5. **Pectin Test:-**
   a. **Jelmeter test:-** A jelmeter is a graduated glass tube with an opening at each end. It is used to determine the amount of pectin in fruit juice. The rate of flow of the juice through this tube is used as a measure of the jellying power of the juice. Therefore, it is an index to the amount of sugar to be used. Jelmeters were once commonly available, but are not easy to find today, most likely because the alcohol test is more reliable.
   b. **Alcohol Test:-** his is a proven standard test for pectin content and luckily it's hard to go wrong with.
      - Take one teaspoon of clear boiling fruit juice and drop into a cold glass or cup, allow it to cool for a minute and then add three teaspoons of methylated spirit and swirl it around or gently shake.
      - If a large clot forms from the juice, adequate pectin for a good set has been extracted and the sugar may be added to the fruit and juice
      - If 2-3 clot formed means pectin content in juice is medium.
      - If 3-4 clot formed means pectin content in juice is low.
      - If there is only a very low amount of pectin, several small clots will form. It is probably going to be worth adding some additional pectin to ensure a good set.

Jelmeter Reading	Alcohol Test	Adding sugar quantity (Kg)
1.25	One large Clot	1.250
1.0	2-3 Clots	1.000
0.75	3-5 Clots	0.750
0.50	Several small clots	Jelly shouldn't make or Adding some synthetic pectin

6. **Cooking juice with sugar:-** Start heating with 1/3 quantity with sugar. After some time add remaining sugar.
7. **Adding of Citric Acid:-** For enhancement of test citric acid should be added at 103^{o}C temperature.
8. **Judging of End-Point:-**

- **Drop test:-** A drop of the concentrated mass is poured into a glass containing water. Settling down of the drop without disintegration denotes the end-point
- **Temperature:-** 105.5^0C.
- **TSS:-** 65%
- **Weight Test:-** If total weight of jam is 1.5 time is more than sugar weight, jam is prepared.

9. **Packing:-** Jam should be fill in glass jar.
10. **Storage:-** Jam should be stored at dry and cool place.

Problems of Jelly making

- **Jelly is failed to set:-** Jelly is failed to set due to addition of too much sugar, lake of acid the end-point, cooking below the end-point, cooking beyond the end-point and prolonged cooking.
- **Cloudy or foggy jelly:-** Cloudy or foggy jelly due to use of non-clarified juice or extract, use of immature fruits, over-cooking, non-removal of scum, faulty pouring and premature gelation.
- **Formation of crystals in jelly:-** Formation of crystals in jelly due to addition of excess sugar and also to over-concentration of jelly.
- **Syneresis or weeping of jelly:-** Syneresis or weeping of jelly is the phenomenon of spontaneous exudation of fluid from a gel is called syneresis and weeping and is caused by excess of acid, too low concentration of sugar, insufficient pectin, premature gelation and fermentation.
- Jelly pasteurized at $82\text{-}85^0$C for 30 minutes.

Marmalade

Marmalade is a fruit jelly in which slices of the citrus fruit or its peels are suspended. Marmalades are generally made from citrus fruits like oranges and lemons in which shredded peels are suspended.

- Browning during storage of marmalade is very common which can be prevented by addition of 0.09g of KMS per kg of marmalade and not using tin container.

Flow-Sheet for Processing of Fruits Jam

Ripe Firm Fruit

↓

Washing

↓

Peeling

↓

Pulping

(Remove seed and core)

↓

Addition of Sugar

(Add water if necessary)

↓

Boiling

(With continuous starring)

↓

Addition of Citric Acid

↓

Judging of End-Point by Further

↓

Cooking upto 105^0C or 68-70% TSS or by Sheet Test

↓

Filling Hot Into Sterilized Bottles

↓

Cooling

↓

Waxing

↓

Capping

↓

Storage

(At ambient temperature)

Flow-Sheet for Processing of Fruits Jelly

Fruits

(Firm, not over-ripe)

↓

Washing

↓

Cutting into thin slices

↓

Boiling with water

($1^1/_2$ times the weight of fruit for about 20-30 minutes)

↓

Addition of citric acid during boiling

(2g per kg of fruit)

↓

Straining of extract

↓

Pectin test

(for addition of sugar)

↓

Addition of sugar

↓

Boiling

↓

Judging of end-point

(sheet/drop/temperature test)

↓

Removal of scum or foam

(one teaspoonful edible oil added for 45 kg sugar)

↓

Colour and remaining citric acid added

↓

Filling hot into clean sterilized bottles

↓

Waxing

(paraffin wax)

↓

Capping

↓

Storage ambient condition

Flow-Sheet for Processing of Marmalade

Ripe Fruits

↓

Washing

↓

Peeling outer yellow portion (Flavedo) thinly

↓

Cutting yellow portion into fine shreds

(1.9-2.5cm long and 0.08-0.12cm thick)

↓

Boiling

(In 2-3 times weight of water for 40 to 60 minutes)

↓

Straining the extract

↓

Testing for pectin content

(Alcohol test)

↓

Adding of sugar

(as required)

↓

Cooking to 103-105^{0}C

(continuous stirring)

↓

Adding of prepared shreds

(Shredded peel boiled for 10-15 minutes in several changes of water for softening and removing bitterness and added @about 62g per kg of extract)

↓

Boiling till jellying point

(continuous stirring)

↓

Testing for end point

(Sheet/drop/temperature test)

↓

Cooking

(to 82-88^{0}C with continues stirring)

↓

Flavoring

(orange oil)

↓

Filling in sterilized bottles

↓

Sealing

↓

Storage at ambient temperature

Preserves, Candied, Crystallized and Glazed fruits and vegetables

Preserves (*Murabbas*) are prepared from whole fruits and vegetables or their segments by addition of sugar followed by evaporation to a point where microbial spoilage cannot occur. The final soluble solids concentration is reached to about 70 per cent. The finished product can be stored without hermetic sealing and refrigeration.

- In preserves fruits can be cooked in syrup by three processes that are: 1) Rapid process, 2) Slow process and 3) Vacuum process.
- Preserves made by vacuum process retain the flavour and colour of the fruit better other methods.
- Most suitable fruits for preserves making are Aonla, beal, apple, pear, mango, cherry, karonda, strawberry, pineapple, papaya, etc.

Candied fruits

Fruits/vegetables impregnated with cane sugar or glucose syrup, and subsequently drained free of syrup and dried, is known as candied fruit/vegetable.

- Most suitable fruits for candied making are Aonla, karonda, pineapple, cherry, papaya, apple, peach and peel of lemon, grapefruit and citron, ginger etc.
- The difference between candied and preserves is that the fruit impregnated with syrup having a higher percentage of sugar or glucose.
- For best candied total sugar content of the impregnated fruit is kept at about 75 per cent to prevent fermentation.

Crystallized fruits/vegetables

Candied fruit/ vegetable when covered or coated with crystals of sugar, either by rolling in finely powdered sugar or by allowing sugar crystals to deposit on them from dense syrup are called crystallized fruits.

Glazed fruits/vegetables

Covering of candied fruits/vegetables with a thin transparent coating of sugar, which impart them a glossy appearance, is known as glazing.

Problems in preparation of preservation and candied fruits

1. Fermentation: It is due to concentration of sugar used in the initial stage of preparation of preserves. Sometime fermentation also occurs during storage due to low concentration of sugar and insufficient cooking. This can be prevented by boiling the product at suitable intervals, by adding the required quantity of sugar and by storage in a cool and dry place.

2. **Floating of fruit in jar:** It is mainly due to filling the preserve without cooling and can be avoided by cooling the preserve prior to filling.

3. Toughening of fruit skin or peel: It may be due to inadequate blanching or cooking of fruit hence blanching till tender is necessary.

4. Fruit shrinkage: Cooking of fruit in heavy syrup greatly reduces absorption of sugar and causes shrinkage. Therefore, fruit should be blanched first or cooked in low-sugar syrup.

5. Stickiness: It may develop after drying or during storage due to insufficient consistency of the syrup, poor quality packing and damp storage conditions.

Flow-Sheet for Processing of Preserve and Candy

Mature Fruit
↓
Washing
↓
Preparation for sugar treatment
(according to fruits and vegetables)
↓
Keeping fruit and sugar in alternate layers
(1 kg fruit: 1kg sugar) or steeping fruit in syrup of 40% TSS for a day
↓
Removal of fruit
↓
Increasing consistency of syrup to 60% TSS by boiling
↓
Steeping of fruit
(for a day)
↓
Repeating the process and raising strength of syrup by 5% TSS to 70% TSS (preserve) or 75% TSS (candy) on alternate days

Preserve:
↓
Steeping in 70% TSS for a week
↓
Preserve
↓
Draining
↓
Filling in jar or container
↓
Covering fruit with freshly prepared sugar syrup of 68% TSS
↓

Candy:
↓
Steeping in 75% TSS for a week
↓
Draining
↓
Shade drying
(prior to drying, fruit dipped in boiling water to remove adhering syrup)
↓
Packing

Storage

Sealing

(airtight)

↓

Storage

↓

Pickle

The preservation of food in common salt or in vinegar is known as pickling. It is one of the most ancient methods of preserving fruits and vegetables. Pickles are good appetizers and add to the palatability of a meal. They stimulate the flow of gastric juice and thus help in digestion. They are prepared with salt, vinegar, oil or with a mixture of salt, oil, spices and vinegar.

Method of pickle preparation

1. **Preservation with salt:** Salt improves the taste and flavour and hardness the tissues of vegetables and controls fermentation. Salt content of 15 per cent or above prevents microbial spoilage. This method of preservation is generally used only for vegetables and some fruits like lime, mango etc. which contain very little sugar and hence sufficient lactic acid cannot be formed by fermentation to act as preservation.

2. **Preservation with vinegar:** The fruits and vegetables preserved in vinegar whose final concentration, in terms of acetic acid in the finished pickle should not be less than 2 per cent.

3. **Preservation with oil:** The fruits and vegetables should be completely immersed in the edible oil. Cauliflower, lime mango and turnip pickles are the most important oil pickles.

4. **Preservation with mixture of salt, oil, spices and vinegar:** The fruits and vegetables can preserve in mixture of salt, oil, spices and vinegar. Cauliflower, carrot, turnip, red chilli, jackfruit and tomato most important pickle those are prepared by this method.

Problems in pickle making

1. Bitter taste: Use of strong vinegar or excess spice or prolonged cooking of spices imparts a taste to the pickle.

2. Blackening: It is due to the iron in the brine or in the process equipment reacting with the ingredient used in pickling. Certain microorganisms also cause blackening.

3. Cloudiness: Cloudiness caused by the use of inferior quality vinegar or chemical reaction between vinegar and minerals.

4. Dull and faded product: This is due to use of inferior quality materials or insufficient curing.

5. Shrivelling: It occurs when vegetables are placed directly in a very strong solution of salt or sugar or vinegar.

6. Scum formation: When vegetables are cured in brine, a white scum always from on the surface due to the growth of wild yeast. This delays the formation of lactic acid and also helps the growth of putrefactive bacteria which cause softness and slipperiness. Addition of 1 per cent acetic acid helps to prevent the growth of wild yeast in brine, without affecting lactic acid formation.

7. Softness and slipperiness: This very common problem is due to inadequate covering with brine or the use of weak brine. The problem can be solved by using a brine of proper strength and keeping the pickles well below the surface of the brine.

FLOW-CHART FOR MANGO PICKLE

Mango (peeled and sliced) -1 kg, salt - 200 g, red chilli powder 10 g, asafetida -5 g, fenugreek, black pepper, cardamom (large), cumin and cinnamon (powdered) each 10 g, clove (headless) 6 numbers.

Mangoes

(Mature, green)

↓

Washing

↓

Peeling

↓

Slicing

↓

Putting slices in jar

↓

Sprinkling salt

↓

Putting in sun for one week

(Shaking jar at least twice in a day to mix the salt)

↓

Mixing spices

↓

Storage at ambient temperature

(In cool and dry place)

FLOW-CHART FOR LIME PICKLE

Select ripe (but not overripe) healthy lime fruits.

↓

Washing

↓

Heat Dip in hot water (60-65^{0}C)

for about five minutes

↓

Cut into four pieces or alternatively cut into smaller, uniform-sized pieces

↓

Brine Ensure that the surface is covered with juice

↓

Dry in the sun for 2-3 days

↓

Mix spices

(To local preference)

↓

Packaging

↓

Storage

(In a cool place, away from sunlight)

FLOW-CHART FOR CUCUMBER PICKLE

Cucumber 1 kg, salt 200 g, red chilli powder 15 g, cardamom (large), cumin, black pepper (powdered) each 10 g, clove (headless) 6 numbers, vinegar 750 ml.

Cucumber

↓

Washing

↓

Peeling

↓

Cutting into 5 cm pieces

↓

Mixing with salt

↓

Filling in jar

↓

Standing for 6-8 hours

↓

Draining off water

↓

Adding spices and vinegar

↓

Keeping in sun for a week

↓

Storage

(In a cool place, away from sunlight)

FLOW-CHART FOR GREEN CHILLI PICKLEPICKLE

Green chillies – 1 kg, salt – 150 gm, mustard (ground) – 100 gm lime juice – 200 ml (or) amchur – 200 gm, fenugreek cardamom (large), turmeric, cumin (powdered) each – 15 gm, mustard oil – 400 ml.

Green chillies

↓

Washing

↓

Drying

↓

Making incision

↓

Mixing all spices in a little lime juice

↓

Mixing with chillies

↓

Filling into jar

↓

Adding lime juice and oil

↓

Keeping in sun for a week

↓

Storage

(In a cool place, away from sunlight)

Sauce

Sauce is a product similar to ketchup, prepared from pulps of tomato or other fruit/vegetable, having TSS not less than 15% and cooked to a suitable consistency with added sugar, salt, spices and vinegar. Sugar, salt, spices, acetic acid all act as partial preservatives. According to FPO specification fruit sauce should have minimum of 15% TSS and 1.2% acidity. Preservatives and colours may also be added for increasing of appearance and storability.

Tomato Ketchup

Ketchup is a product made by concentrating tomato juice or pulp without seeds and skin, with added spices, salt, vinegar, onion, garlic etc. so that it content not less than 12% tomato solids and generally 28% or more total solid (not less than 25% TSS as per FPO specificartion).

Sauce and ketchup are similar products but ketchup is only prepared from tomato while sauce may be made by another fruit and vegetable pulp.

Difference between Ketchup and Sauce

Ketchup	Sauce
1. Prepared from tomato only.	1. Prepared from tomato as well as other fruits and vegetables such as pumpkin, chilli, etc.
2. Minimum TSS is 25%.	2. Minimum TSS is 15%.
3. Minimum acidity is 1.0%.	3. Minimum acidity is 1.2%.
4. Thicker in consistency.	4. Thinner in consistency.
5. Costly	5. Cheep as compared to ketchup.
6. Only red in colour.	6. May have red, green or other colours.

Flowchart for Processing of Tomato Ketchup/Sauce

Tomatoes
(Fully ripe, red)
↓
Washing and Sorting
↓
Cutting and Chopping
↓
Heating at 70-90^{o}C for 3-5 minutes
(To soften)
↓
Straining tomato pulp/juice
↓
Pulping
↓
Cooking pulp with 1/3 quantity of sugar
↓
Putting spice bag
↓
Cooking to 1/3 of original volume of pulp/juice
↓
Removal of spice bag

(After squeezing in pulp)

↓

Cooking and addition of remaining sugar and salt

↓

Judging of end-point
(Tomato solids)

↓

Addition of vinegar/acetic acid and preservative

↓

Filling and cooling

↓

Pasteurization

↓

Crown crocking

↓

Storage at ambient temperature
(In cool and dry place)

3 Packaging, Quality Slandered and Their Marketing Including Export

Packaging is an important consideration in vegetable and fruit market. The use of properly designed containers for transporting and marketing of vegetables is significantly reduce losses and maintain their freshness succulence and quality for longer period. Packaging also provides protection from mechanical damage and undesirable physiological changes and pathological deterioration during storage, transportation and marketing.

Many vegetables are transported in gunny bags and bamboo baskets. Packaging material such as polythene films, paper boars, and boxes lived with polythene and other materials can effectively prolong the shelf life of vegetables. By using plastic films vegetables can be protected from dry air. Polythene packaging provides modified atmosphere and consequently reduces decay, softening, and loss of solids. The thickness and permeability to CO_2, O_2 and water vapour of films needs to be standardized for each vegetable.

The Function of Packaging or Why package Produce?

A significant percentage of produce buyer and consumer complaints may be traced to container failure because of poor design or inappropriate selection and use. A properly designed produce container should contain, protect, and identify the produce, satisfying everyone from grower to consumer.

The main objective of packaging is to keep the fruits, vegetable and root crops in good condition until it is sold and consumed.

Characteristics of packaging

The characteristics of packaging are to contain, to protect, to communicate and to market the product.

A. To contain produce

- As an efficient handling unit, easy to be handled by one person.
- As a marketable unit. e.g. units with the same content and weight.

B. To protect produce against

- Rough handling during loading, unloading and transport - rigid crate.
- Pressure during stacking.
- Moisture or water loss with consequent weight and appearance loss.
- Heat: air flow through crate or box via ventilation holes.
- Fumigation possible through ventilation holes.

C. To communicate

- Identification: a label with country of origin, volume, type or variety of product, manufacturing and expiry date, etc. printed on it.
- Marketing, advertising: recognizable trade name and trademark.

D. To market the product

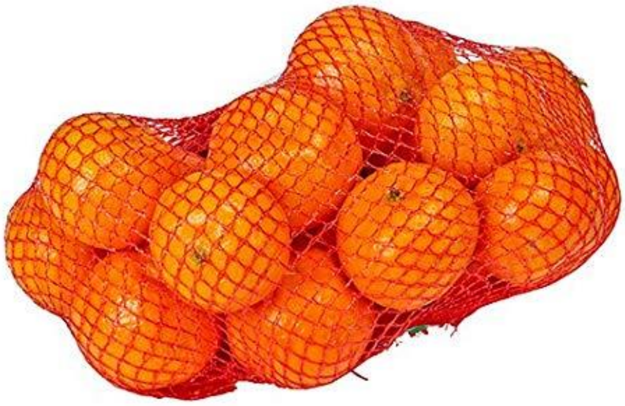
- Proper packaging will lead to reduced injuries of fruits and vegetables and subsequently to improvement of appearance.
- Standard units (weight, count) of a certain produce will increase speed and efficiency of marketing.
- With reduced costs of transport and handling, stacking and combining of packages into layer units like pallets is possible. A more efficient use of space and reduced losses will lower the marketing costs.
- Labels and slots facilitate inspection.

Type of packaging

1) Plastic film bags: – Widely used for consumer size packs in fruit and vegetables marketing.

2) Plastic boxes: – They are rigid containers most suited for packaging soft and delicate commodities.

3) Net / mesh bags: – Widely used for packing fruits like apple, citrus, guava, sapota *etc.*



4) **Sleeve packs: –** Immobilization of packed fruits, superior visibility that gives a good sales appeal.

5) Cling film: – Ideal packaging for low water vapour transmission rate, high gas permeability.

6) Shrink film or stretch film: – Among the specialised plastic packaging systems, shrink packaging or commonly known as shrink wrapping and stretch wrapping are very common and widely used. ey are considered to be totally different in terms of material and operation.

In the case of shrink wrapping, shrink film is used as the basic material and heat forms an important part of the operation, whereas, in the case of stretch wrapping, stretch film is used as the basic material and no heat is applied during the operation. Shrink Wrapping is done in 3 or 4 stages, namely:

• Wrapping (sleeve wrapping or over-wrapping)

• Sealing (necessary only for over-wrapping)

• Shrinking (with application of hot air), and

• Cooling

Stretch wrapping is done only in two stages, namely, wrapping and sealing (most of the time even without a sealer).

7) Antimicrobial packaging: – Incorporating antimicrobial agents into polymer surface coating sand surface attachments.

8) Wooden packaging: – used for packing fruits and vegetable.

The advantages of wooden crates are:

- The crates can be manufactured and repaired locally.
- Wood is relatively resistant to different weather conditions and (sea) water.
- Wooden crates are often used on more than one journey and have a higher efficiency for larger fruits, e.g. watermelons.
- Most crates have good ventilation and fast pre-cooling is possible.

Disadvantages of wooden crates are:

- Untreated wood can easily become contaminated with fungi and bacteria.
- Treatment of wooden crates with paint or other chemicals may cause produce deterioration.
- The material may be too hard or rough for produce like soft fruits, and therefore liners of a soft material may be needed.
- Disposal of the crates after use.
- Manufacturing of wooden crates puts an extra claim on the natural forest resources.

9) Modified atmosphere packaging

It is the packaging of perishable products. Modified atmosphere packaging (MAP) of fresh fruits and vegetables is based on modifying the levels of O_2 and CO_2 in the atmosphere produced inside a package sealed with some type of polymer film. It is desirable that the natural interaction that occurs between the respiration of the product and the packaging generates an atmosphere with low levels of O_2 and / or a high concentration of CO_2. The growth of organisms that cause decay is thereby reduced and the life of the product is extended. Additionally, the desired atmosphere can reduce the respiration rate, and ethylene production, physiological changes. For example, it can inhibit chemical, enzymatic and microbiological mechanisms associated with the decay of fresh products, thus avoiding the use of other chemical or thermal process such as freezing, dehydration, and sterilization. Modified atmosphere packaging is two types:-

Passive Modified atmosphere packaging

Modified atmospheres can be obtained passively between plant material and sealed package or intentionally using determined concentrations of gases. Modified atmosphere is formed as a result of vegetable respiration, which consumes CO_2 and releases O_2 in sealed package. In passive modification, the respiring product is placed in a polymeric package and sealed hermetically. Only the respiration of the product and the gas permeability of the film influence the change in gaseous composition of the environment surrounding the product. If the product's respiration characteristics are properly matched to the film permeability values, then a beneficial modified atmosphere can be passively created within a package. The polymer itself variably restricts gas exchange between the internal and external environments due to its selective permeability to O_2 and CO_2. After a period of time, the Modified Atmosphere Packaging for Perishable Plant Products system reaches an equilibrium atmosphere containing of lower concentrations of O_2 and higher concentrations of CO_2 than in atmospheric air.

Active Modified atmosphere packaging

The concept of active packaging has been developed to adjust the deficiencies in passive packaging such as when a film is a good barrier to moisture, but not to oxygen, the film can still be used along with an oxygen scavenger to exclude oxygen from the pack. An intentionally or actively obtained modified atmosphere occurs when the desired gas mixture is introduced into the container before sealing. In this way, atmospheric balance inside the package is reached faster or almost immediately. Sometimes, certain additives are incorporated into the polymeric packaging film or within packaging containers to modify the headspace atmosphere and to extend shelf-life. Another process is the acceleration of atmospheric balance under partial vacuum packaging is the process of removing the air before sealing, reducing the free space. Although the active modification of the atmosphere within the package incurs additional costs, the advantage is that the desired atmosphere is securely achieved in considerably less time.

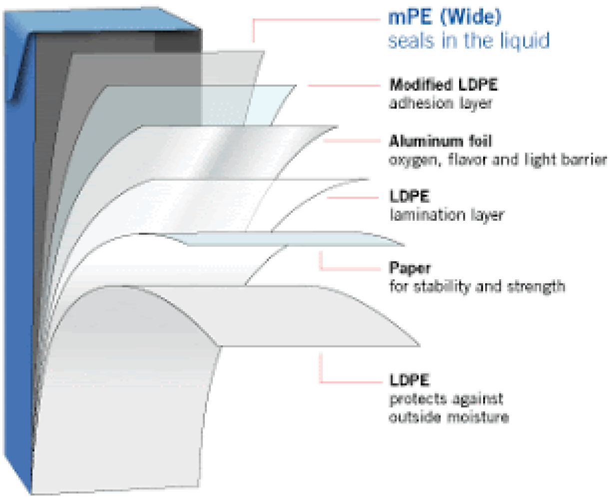
10) Vacuum packaging: – Where as MAP and CAP mostly operate in ambient pressure (101 kpa), storage at reduced atmosphere has been experimented and is known as vaccum packaging. Packaging the products in film of low oxygen permeability and sealing it after evacuating the air. Apple can be stored well in below pressure of 10 kpa.

12) Bamboo mat holed boxes: -Suitable for transportation of apple.

13) Polypropelene boxes: - Highly suitable for long markets it can be reused.

14) Corrugated fibre board: -Suitable for fruit and vegetable and most economical.

15) **Tetra-packaging:-** Tetra Pak aseptic cartons are made of three basic materials that together result in every efficient, safe and light-weight package. Each material provides a specific function:



1.Polyethylene: Protects against moisture

2. Paper: For stability & strength

3. Polyethylene: Adhesion

4. Aluminium: Barrier to oxygen, flavour & light

5. Polyethylene: Adhesion

6. Polyethylene: Seals in the liquid

It is used to store the fruit beverages and RTS beverages.

- Paper (80%): to provide strength and stiffness

- Polyethylene (15%): to make packages liquid tight and to provide a barrier to micro - organisms
- Aluminium foils (5%): to keep out air, light, and off-flavours-all the things that can cause food to deteriorate.

Combining each of these three materials has enabled Tetra Pak to produce a packaging material with optimal properties and excellent performance characteristics.

- Higher degree of safety, hygiene and nutrient retention in food
- Preserving taste and freshness
- Can be kept for months with no need for refrigeration or preservatives
- Efficient (a filled package weight is 97% product and only 3% packaging material), using a minimum quantity of materials necessary to achieve a given function
- A good example of resource efficiency is its light-weight (among the lightest packages available)

Type of packaging materials

1. Sacks: flexible, made of plastic or jute.
   i. Bags: small size sack
   ii. Nets: sacks made of open mesh
2. Wooden crates.
3. Carton or fiber-board boxes.
4. Plastic crates.
5. Pallet boxes and shipping containers.
6. Baskets: made of woven strips of leaves, bamboo, plastic, etc.

5 CONCEPT OF SAFE FOOD AND QUALITY STANDARD

Quality Standards and Laws

Quality is how well a product or service satisfies the needs of the customer. This includes all aspects related to the needs of the customer such as quality specifications, safetgy, delivery method or date, price etc. Quality can be interpreted in several ways as conformance to the standards, meeting customers' preference/ satisfaction for desired quality attributes, degree of excellence and zero defect products etc. Because of education and consequent greater understanding of implications of poor quality commodities in recent years, consumers have become quality conscious and this fact is also applicable to food and food products. In order to strengthen competitiveness, quality must be incorporated throughout the value added chains right from the harvesting, handling, manufacturing, processing, packaging, storage, marketing and distribution stages, especially in the case of food and food products.

Elements of Food Quality and Safety

The basic functions of a quality control programme are:

- Physical and chemical evaluation of raw materials and processed products
- In-process control of :
  - ✓ Raw materials, ingredients and packaging supplies
  - ✓ Processing parameters
  - ✓ Finished products
- Microbiological analysis and their control in raw materials and finished products
- Control of storage and handling conditions
- Sanitation and waste products control
- Assurance that final products are within the legal and established marketing standards

Steps for ensuring food quality

Quality Control and Quality Assurance are the two steps for ensuring quality. Quality Control is the evaluation of a final product prior to its marketing i.e., it is based on quality checks at the end of production. Quality Assurance is similar to quality control, but has more to do with the process than the product. It is the implementation of quality checks and procedures to immediately correct any failure and mistake that is able to reduce the quality of the interim products at every production step.

The desired high quality of the final product is planned and obtained by conducting Standard Operating Procedures (SOP) that guarantee the desired quality of the interim products at every production step meeting the demands for Good Manufacturing Practices (GMPs). The management approach to long-term success through customer satisfaction is based on the participation of all members of an organization in improving processes, products, services and the working culture and is known as Total Quality Management (TQM). These are the systems that can demonstrate that the organization can meet the specifications and requirements of the customers. They also allow the management of the organization to know that the customer's requirements are being met. Food quality profile for any product is depicted under:

Physical	Chemical	Sensory	Nutritive	Convenience	Microbial
Size	Proximate composition	Appearance	Vitamins	Processing	Total load
Shape	Deteriorative parameters	Colour	Minerals	Shelf life	Yeasts
Viscosity		Smell	Dietary fiber	Packagin	Pathogens
Thickness		Texture	Energy content		Moulds
		Flavour	Antioxidants		

Good Manufacturing Practices (GMPs) are guidelines to assure that food for human consumption is safe and has been prepared, packed and held under sanitary conditions. These guidelines deal with personnel involved in food processing, building, premises as well as construction and design.

Quality Systems

Food Laws: There are a number of food laws being implemented by various Ministries/Departments. These are primarily meant for two purposes namely, (1) Regulation of Specifications of Food and (2) Regulation of Hygienic Condition of Processing/Manufacturing. Some of these food laws are mandatory and some are voluntary. Food laws are set up and established by authorities as a rule for the measure of quantity, weight, value or quality. Food laws are essential to provide uniform units for weights and measures. The purpose/ benefits of food laws are helpful for farmers and other people engaged in harvesting and food production, those who are engaged in processing and marketing of food, for consumers and government agencies.

Legislations Governing Food Industry in India: With trade liberalization and globalization in the food industry after WTO we have to amend / make changes in our legislations to meet international requirements. In our country, standardization systems fall into two categories. Compulsory legislations are formulated by various Ministries whereas voluntary standards are framed by the organizations with the motto of serving the country. The details of

Acts/Orders, their mode of operation, regulations with special features are described in Table 3. Different voluntary legislations are made for the purpose to guarantee stated quality and sales promotion. A number of control orders have been formulated under the provisions of the Essential Commodities Act, which operate on the main objectives of regulating the manufacture, commerce and distribution of essential commodities. There are various commodity boards such as Spices Board, Tea Board, Coffee Board, National Horticulture Board operating in India which undertake research and development work for their respective fields**.**

International Organizations Governing Food Safety

- World Health Organization (WHO)
- World Trade Organization (WTO)
- Food and Agriculture Organization (FAO)
- Codex Alimentarius Commission (CAC) (Under FAO/ WHO)
- International Organization for Standardization (ISO)
- International Association of Milk, Food and Environmental Sanitarians (IAMFES)
- International Commission for Microbiological Specifications for Foods (ICMSF)
- National Advisory Committee for Microbiological Criteria for Foods (NACMCF)
- International Dairy Federation (IDF)
- Her Majesty's Stationary Office (HMSO)

International Organization for Standardization (ISO)

International Organization for Standardization (ISO) is based in Geneva, Switzerland. Founded in 1947 for the purpose of advancing standardization around the world, this non-government organization is now comprised of over 130 member countries. The ISO 9000 series of quality management standards were developed by the ISO/TC 176 (ISO Technical Committee 176) convened in 1979. It sets out to create a series of internationally recognized quality management standards that represent the essential requirements that every enterprise needs to address to ensure the consistent production and timely delivery of its goods and services to the marketplace. These requirements make up the standards that comprise the quality management system. The ISO 9000 series is able to provide these quality management benefits to any organization of any size, public or private, without dictating how the organization is to be run. The series contains four system standards of varying complexity and completeness which are: ISO 9001, ISO 9002, ISO 9003 and ISO 9004.

The ISO/TC 207 convened in 1993, developed the ISO 14000 series of environmental management standards. The ISO 14000 series of standards represent the essential requirements that every enterprise needs to address in order to control and minimize the impact that its operation, and resulting goods and services, has on the environment.

Codex Alimentarius Commission (CAC)

The Codex Alimentarius Commission (CAC) was created in 1963 by FAO and WHO to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purpose of this programme is protecting health of the consumers, ensuring fair trade practices in the food trade and promoting coordination of all food standards work undertaken by international government and non-government organizations.

Hazard Analysis and Critical Control Point (HACCP)

Hazard Analysis and Critical Control Point (HACCP) is a food safety programme that was developed nearly 30 years ago for NASA to ensure the safety of food products that were to be used by the astronauts in the space programme. HACCP involves a systems approach for identification of hazards, assessment of chances of occurrence of hazards during each phase, raw material procurement, manufacturing, and distribution, usage of food products and in defining the measures for hazard control.

HACCP is comprised of seven principles

1) Analyze hazards – Potential hazards associated with a food and the measures required to control those hazards are identified that include biological, chemical and physical contaminants.
2) Identify critical control points (CCP). These are points in a food's production at which potential hazards can be controlled or eliminated.
3) Establish preventative measures with critical limits for each control point. These are minimum standards required for the safe preparation of food.
4) Establish procedures to monitor the critical control points. Such procedures include determining how and by whom processing standards are to be monitored.
5) Establish corrective actions to be taken when monitoring has shown that a critical limit has not been met. Therefore, either reprocess or dispose off foods if minimum processing standards have not been met.
6) Establish procedures to verify that the system is working properly for testing and calibrating equipment to ensure their proper functioning which is one typical requirement.
7) Establish effective record keeping in order to document the HACCP system. This would include records of hazards and their control methods, monitoring of safety requirements and corrective actions taken to either prevent problems or how non-conformances are to be prevented from reoccurring.

HACCP enables the producers, processors, distributors, exporters etc., of food products to utilize technical resources efficiently and in a cost effective manner for ensuring food safety. For food industry in India, adoption of HACCP is becoming imperative to reach global standards, demonstrate compliance to regulations/ customer requirements besides providing safer food at all times. HACCP helps in the reduction of contamination, reduction recalling/ product destruction, providing market protection, providing preferred supplier status, demonstrating conformance to international standards, transforming commodities into branded products and facilitating international acceptance.

Standardization systems for quality control of foods

S.N	Act / Order	Mode of Operation	Regulations	Special Features
I. Compulsory legislations				
1.	Prevention of Food Adulteration (PFA) Act, 1954	i)Ministry of Health & Family Welfare ii)Directorate General of Health Services iii)Central Committee for Food Standards	Makes provisions for prevention of adulteration of food. Adulterated, misbranded, and not in accordance with the conditions of license shall be prohibited for selling. No such food shall be imported. Standards for the commodities have been specified in the rules. Proprietary foods shall specify the ingredients in the product in the descending order of their composition of the label.	Minimum quality standards. Ensure safety against harmful impurities, adulteration. Mandatory law Non-following of PFA Act lead to fine and imprisonment.
2.	Atomic Energy Rules, 1991 (Control of irradiation of food)	Department of Atomic Energy	Regulates the irradiation application in foods. Certificate with the dose and purpose is insisted upon.	Certificate of irradiation indicating the dose and the purpose shall be provided by the competent authority.
3.	Essential Commodity Act, 1954	Ministry of Food	Regulates the manufacture of commodities, commerce and distribution.	Formations of other suborders for easy implementation.
4	Fruit Products Order (FPO), 1955	Ministry of Food Processing Industry Central Food Products Advisory Committee	Regulates the manufacture and distribution of all fruit and vegetable products. Exempted from the provisions of the order to products prepared by Drug Control Act and Educational Institutions for training purposes. Quantity shall not exceed 10 kg. License shall be issued after the satisfaction of quality of product, sanitation, personnel hygiene, machinery, equipment and work area requirements as per the schedule specified.	Licensing authority 'FPO' standard mark shall be imprinted on the products
5	Vegetable Oil	Ministry of Food	Regulates the production and	Supersedes the Vegetable

	Products (Regulation) Order, 1998	and Consumer Affairs	distribution of all the edible oils. Specifications of the products provided.	Oil Products (Control) Order, 1947 and Vegetable Oil Products (Standards of Quality) Order, 1975. BIS Certification for the tin plates used for "*Vanaspati*" packing is deleted.
6.	Sugar (Control) Order, 1966	Ministry of Agriculture and Irrigation Department of Sugar	Regulates the manufacture, quality and sale of sugar.	
7.	Export (Quality Control & Inspection) Act, 1963	Ministry of Commerce Export Inspection Council 5 Regional Export Inspection Agencies Network of 50 Offices	Regulates compulsory, pre-shipment inspection. Exportable commodities list has been notified for pre-shipment inspection. Quality control of various export products is monitored.	AGMARK has been recognized as an agent for inspection and quality control of certain items. Voluntary inspection at the request of foreign buyers and advice of Export Inspection Council is also carried out.
8.	Standards on Weights and Measures Act, 1976	Ministry of Food and Civil Supplies Directorate of Weights and Measures	Prescribed the conditions for packed products with respect to quantity declaration, manufacturing date and sale price.	Providing relief to the weaker sections of society and protecting the consumer in general by guaranteeing the quantity for the amount paid.
9.	The Consumer Protection Act, 1986	Ministry of Food and Civil Supplies	Provision made for the establishment of consumer councils and other authorities for the settlement of consumer disputes.	Protection of the interest of Consumers.
10.	Environ-ment Protection Act, 1986	Ministry of Environment and Forestry	Regulates the manufacture, use and storage of hazardous microorganisms /substances/cells used as foodstuff.	Compulsory for every food plant discharging waste into mainstream to obtain a No Objection Certificate (NOC) from respective State Pollution Board.

11.	The Insecticide Act, 1968	Directorate of Plant Protection, Quarantine and Storage, Ministry of Agriculture	Describes the safe use of insecticides to ensure that residual level doesn't pose any health hazard.	
II. Voluntary Standards				
1.	Agricultural Produce (Grading & Marketing) Act, 1937	Directorate of Marketing and Inspection	Grade Standards are prescribed for Agricultural and Allied Commodities Grading, sorting as per quality attributes and inspection are included.	Activity is based on marketing and grading at producers' level. Non-following of rules leads to fine and imprisonment. AGMARK Certificate System available.
2.	Bureau of Indian Standards (BIS)	Indian Standards Institution	Prescribing of grade standards, formulation of standards, and specification for foods, prescribing standards for limits of toxic compounds as applicable. Implementation of regulation by promotion through its voluntary and third party certification system, specifying of packaging and labeling requirements.	General cover on hygienic conditions of manufacture, raw material quality and safety are given. Quality and Safety oriented standards. Enforces certification system.
3.	Certification Marks Scheme, BIS Act, 1986 (Rules and Regulations)	Bureau of Indian Standards	Regulates the certification scheme for various processed food products, ingredients and packaging containers.	Ensure the quality to the consumer by certification.

UNIT V: Subsidiary Enterprises of Agriculture

1. APICULTURE, LAC CULTURE AND SERICULTURE

1 APICULTURE

- **Apiculture is also known as bee-keeping.**

'Apis' means bee. The scientific names of different species of honeybees begin with the generic name *Apis*. Apiculture or bee-keeping is the art of caring for, and manipulating colonies of honeybee in large quantity, over and above their own requirement.

History

The first evidence of this association came to light from the rock paintings made by primitive human. Thousands of years ago, Egyptian were well acquainted with bee keeping before the Christian Era. In Rigveda, there are many references to bee and honey. Bee-keeping became a commercial proposition during the 19^{th} century as a result of scientific research. Apiculture is a flourishing industry in many advanced countries like USA, Canada, Germany and Australia.

Importance of bee keeping

There are three main advantages of bee-keeping:

2. Provides honey - a valuable nutritional food
3. Provides bees wax - which has many uses in industry
4. Honey bees are excellent pollinating agents, thus increasing agricultural yields. In terms of actual value this advantage exceeds the other two.

Species of honey bee

There are four common species of honey bee under a single genus *Apis* (apis = bee):

5. ***Apis dorsata* (The rock- bee):-** This is the largest honeybee. Builds single large open comb on high branches of trees and rocks. Produces large quantity of honey, but this bee is difficult to domesticate. This bee is ferocious, stings severely causing fever and sometimes even death.
6. ***Apis indica* (The Indian bee):-** It is Medium sized in size. Hive consists of several parallel combs in dark places such as cavities of tree trunks, mud walls, earthen posts, etc.This bee is not so ferocious and can be domesticated
7. ***Apis florea* (The little bee):-** It is Medium sized in size. Builds single small combs in bushes, hedges, etc. Honey yield is poor.
8. ***Apis mellifera* (The European bee):-** Somewhat like the Indian bee (*Apis indica*). This has been introducted in many parts of the world including India. It is easily domesticated.

The bee colony – various castes and their activities :- A honey bee colony has three castes

- Queen – only one; functional female
- Workers – 20,000-30,000, sterile females
- Drones – a few only, functional males available prior to swarming.

Queen Bee:-

- Queen bee is the only perfectly developed female, that is has well developed ovaries and other organs of female reproductive system.
- She is largest in size.
- Its wings are smaller and are shrivelled.
- Mouth parts for sucking food is shorter than that of workers. No wax glands.
- Live for about 3 - 4 years.
- May lay eggs at the rate of 800 - 1500 per day.

Events in the life of queen bee

Usually at the age of 7-10 days in her parent hive, after the old mother queen along with some workers had left for starting another hive, this new virgin queen goes out for marriage (nuptial) flights. The drones from the same hive chase her. This swarm may also be joined by drones (male bees) from other hives. Mating takes place, while flying, on an average, the queen mates with about six drones and then returns to the hive. The sperms she has received are enough for her whole life, and she never mates again.

The queen has a control mechanism on the release of the sperms from the spermatheca (sperm store). She can lay two types of eggs:

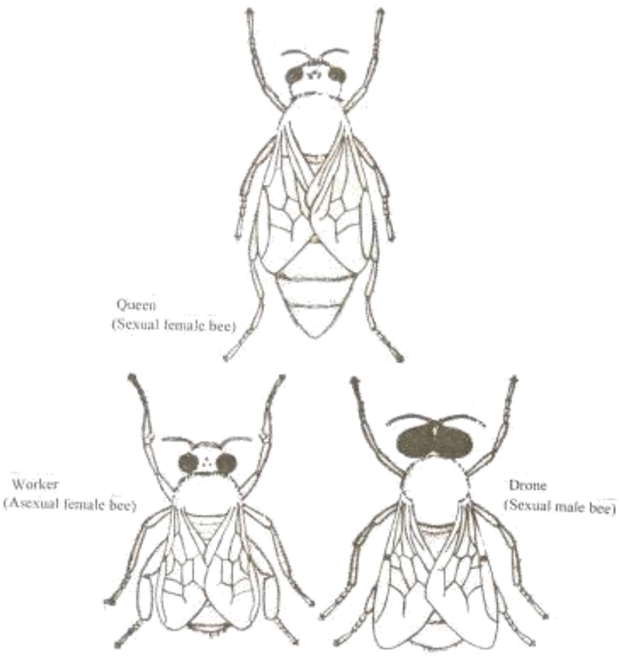
Various castes of honey bee.

(ii) Fertilized – eggs that produce females (either sterile workers or fertile females (new queens).

(iii)Unfertilised – eggs which produce drones.

Worker bees

- Worker bees are imperfectly developed females.
- These are smaller than the queen.
- These have strong wings to fly.
- These have a large and efficient proboscis (mouth parts packed together like a thin tube) for sucking nectar.



- A well-developed sting is present.
- Hind legs have "pollen basket" for collecting pollen.
- The workers have a life span of about 35 days. The different duties which they perform age-wise are as follows:
  - ✓ Day 1-14 Activity inside the hive such as cleaning the hive, feeding the larvae, etc.
  - ✓ Day 14-20 Guard duties at entrance to the hive
  - ✓ Day 21- 35 Foraging, i.e. collecting the food (nectar and pollen from the surroundings)

For foraging, some scout bees set out in the morning. On locating good sources of nectar (i.e. flowers) they return to their hive and perform characteristic movements (bee dances) at the comb. These dances communicate to the other worker bees the distance and the direction of the food source. This is how more and more worker bees are deployed in food gathering. The workers visit flower to flower, collect nectar and pollen and return to their own nest against taking clue from the position of Sun as well as by certain amount of memory and finally the smell of their own particular hive.

The bee dance:- In this dance the middle course of the dance communicates to the other bees the angle from the hive with reference to the sun. Taking a hint from this angle they have to fly to reach the food source.

(iii) Drones:- Drones are the male bees produced from unfertilised eggs. Their production in the hive synchronises with the production of the new (virgin) queens. At the age of 14-18 days the drones perform mating flight chasing the virgin queen in the air. Drones can live up to about 60 days, although they are stung and killed after the mating.

The schematic representation of formation of different castes of bees is shown in.

Queen lays

Unifertilized Eggs
↓
Hatch into Larvae
↓
For first few days fed on "Royal jelly" (Saliva of workers) then on honey and pre-digested pollen
↓
Pupa
↓
Drones

Fertilized Eggs
↓
Hatch into Larvae
↓
Fed on "royal jelly" for first few days.

Royal jelly replaced by honey and pre digested pollen
↓
Pupae
↓
Workers

Royal jelly feeding continued
↓
Pupae
↓
Queen

Schematic representation of the formation of different castes in honeybee.

Emergence of new Queen, and Swarming of the old one

When the queen gets older (usually in the third year) her body gives out a chemical stimulus to the workers to construct a few rearing cells for queens. She places one fertilized egg in each of such brood cells. The larvae are fed on royal jelly (saliva of workers). They turn into pupae and then into queens. The first queen to emerge from the brood cells, kills the remaining ones.

Now the old queen takes to swarming along with a mixture of workers of all ages, leaves the old hive to develop a colony at some new site.

The new queen in the old hive takes to mating flight with the drones and returns to the same hive, as described earlier.

Apiculture and commercial production of honey

Bees produce honey and wax both of which are valuable and marketable commodities.

(a) Indigenous methods of bee keeping

Many villagers make (i) wall or fixed types of hives in rectangular spaces in the walls with a small hole or (ii) movable types of hives in wooden boxes or earthen pitchers. The traditional beekeepers catch clustered swarms from trees, bushes, etc and transfer them to the above-mentioned spaces. After sometime when the honeyis ready, the bees are driven away from the comb usually by smoking the hive. Then the comb is cut away and the honey is squeezed out through a piece of large - meshed cloth.

(b) Modern hives

The modern beehive is made up of a series of square or oblong boxes without tops or bottoms, set one above the other. This hive has the floor at the bottom, and a crown board at the top, and a roof over all. Inside these boxes, wooden frames are vertically hung paralled to each other. The wooden frames are filled with sheets of wax foundation on which the combs are built by the bees. The only entrance to the hive is below the large bottom box (brood chamber). The queen is usually confined to the brood chamber. The boxes termed “supers” are used for storage of honey. The queen is prevented from going to the “supers” by the “queen excluder” that allows only the workers to move.

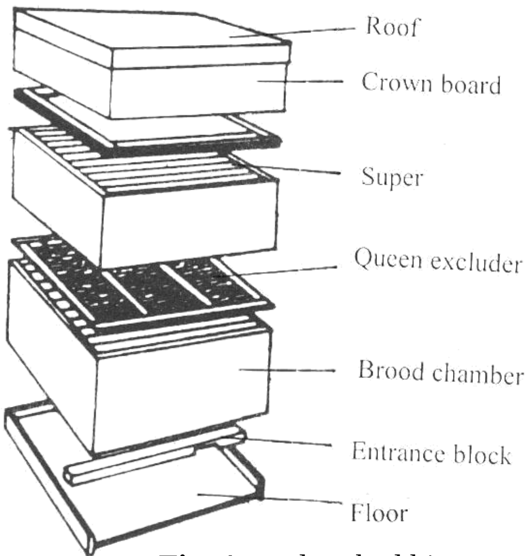


Fig. A modern bed hive.

Catching a swarm

You have already read what a swarm is. It is an old queen accompanied by huge population of workers flying to start a new hive. Swarms are collected from where they are settled. Some kind of a container is needed to collect the bees. The container is usually a straw basket (skep) with a lid.

Hiving a Swarm

It is the process in which the collected swarm is transferred to the hive to build up the colony and produce honey. It is operated in two ways:

(i) Traditional method

- The hive is set up with brood chamber filled with its full number of frames. Each frame has a full sheet of foundation and there is a crown board with roof at the top.
- A sloping board with white sheet is set against the entrance of the hive.
- Bees in the skep (basket) are knocked out of it on to the slope.
- The instinct of the bees to move upwards onto the dark, drives them onto the hive through the entrance.

(ii) Quick method

- In this method the crown board of the hive is taken off, frames are also taken off and the entrance is closed.
- The skep is intimately united with the hive and the bees are poured into the brood chamber from the top.
- The frames containing the wax foundation are placed in the hive.
- The crown board is put back in its position and the entrance is opened.
- It must be seen that the queen enters the hive. Now, sugar syrup must be fed to the swarm, as this feeding will help the bees to settle down to work in their new home.

Bee Pasturage

- The plants that yield nectar and pollen are collectively termed "bee pasturage". The fruit trees, ornamental plants and forest trees comprise important bee pasturage.
- Nectar is the sweet secretion of the flowers. It is raw material for honey.
- Pollen provides the raw material necessary for the major food of the brood.

Products from a bee hive

A. Honey

Honey is a food material for the bees and their larvae. Large quantities of honey are stored in the hive to meet the demands in scarcity. Chemically, honey is a viscous water solution of sugar. Its approximate composition in percentage is as follows:

Water	13-20
Fructose	40-50
Glucose	2-3
Minerals	Traces

Vitamins (B_1, B_2, C)	(minute quantities)

- Composition of honey and its different flavours depend on the kinds of flowers from which the nectar is collected.
- Nectar is sucked from flowers and mixed with saliva. It is swallowed into a special region of the gut called honey stomach. Nectar is a disaccharide (sucrose) it is hydrolysed by the salivary amylase to produce monosaccharides (fructose and glucose).
- Inside the hive the workers regurgitate the processed nectar. The honey thus produced is still very dilute. After placing this honey onto the storage cells of the hive the bees “fan” with their wings to evaporate the excess water and bring the honey to its required concentration.
- Extraction of honey from the combs is done by centrifugation.

Uses of Honey

Some uses of honey are as follows:-

A. Food

- Honey is a nutritious food, rich in energy and vitamins.
- Medicines: It is used as a carrier in ayurvedic and unani medicines. It acts as a laxative and prevents cold, cough and fever.
- It is used in religious ceremonies.
- It goes in the making of alcoholic drinks and beauty lotions.
- Another important use is in scientific research for making bacterial cultures.
- It is also utilised for making poison baits for certain insect pests.

Purity Standards

There is no ready method to test the purity of honey by the customers. Homogenous granulation is a probable sign of its purity. Otherwise there are laboratory methods for testing (test for monosaccharides).

B. Beeswax

Beeswax is secreted by the wax glands located on the underside of the last four abdominal segments (4^{th} to 7^{th}) of the worker bee. This wax is used in constructing bee combs in which the colony of the bees develops.

Uses of beeswax

Some uses are as follows:

- Making of candles (the modern candles are made of paraffin wax, a petroleum product);
- Making pharmaceutical preparations;
- Preparation of varnishes and paints;
- Water proofing and waxing of threads; and
- Formation of comb foundation (wax foundation in apiaries).

Dance Language of the Honey Bee:-

Social behavior in bees has a number of advantages. One of the most important of these is the ability to quickly mobilize a large number of foragers to gather floral resources that may only be available for a short period of time. The ability to communicate location with such precision is one of the most interesting behaviors of a very interesting insect.

The recruitment of foragers from a hive begins when a scout bee returns to the hive engorged with nectar from a newly found nectar source. She begins by spending 30-45 seconds regurgitating and distributing nectar to bees waiting in the hive. Once her generosity has garnered an audience, the dancing begins. There are 2 types of bee dances: the round dance and the tail-wagging or waggle dance, with a transitional form known as the sickle dance.

In all cases the quality and quantity of the food source determines the liveliness of the dances. If the nectar source is of excellent quality, nearly all foragers will dance enthusiastically and at length each time they return from foraging. Food sources of lower quality will produce fewer, shorter, and less vigorous dances; recruiting fewer new foragers.

The Round Dance

The round dance is used for food sources 25-100 meters away from the hive or closer. After distributing some of her new-found nectar to waiting bees the scout will begin running in a small circle, switching direction every so often. After the dance ends food is again distributed at this or some other place on the comb and the dance may be repeated three or (rarely) more times.

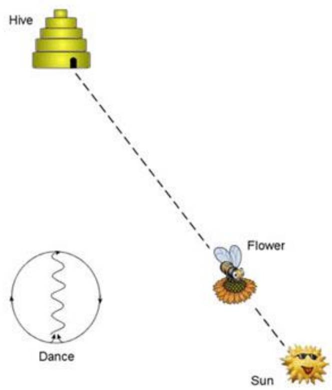
The round dance does not give directional information. Bees elicited into foraging after a round dance fly out of the hive in all directions searching for the food source they know must be there. Odor helps recruited bees find the new flowers in two ways. Bees watching the dance detect fragrance of the flower left on the dancing bee. Additionally, the scout bee leaves odor from its scent gland on the flower that helps guide the recruits.

The Waggle Dance

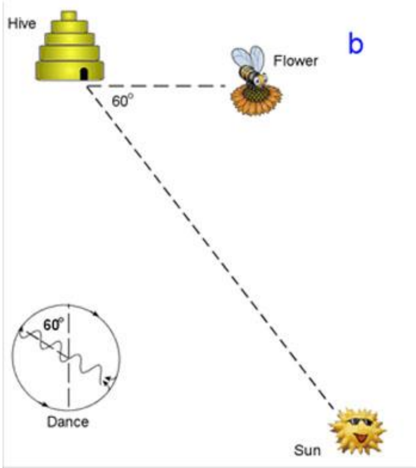
As the food source becomes more distant the round dance is replaced by the waggle dance. There is a gradual transition between the round and waggle dance, taking place through either a figure eight or sickle shaped pattern.

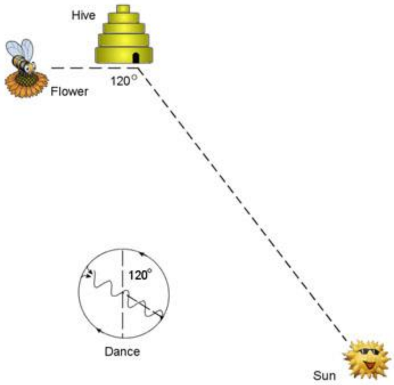
The waggle dance includes information about the direction and energy required to fly to the goal. Energy expenditure (or distance) is indicated by the length of time it takes to make one circuit. For example a bee may dance 8-9 circuits in 15 seconds for a food source 200 meters away, 4-5 for a food source 1000 meters away, and 3 circuits in 15 seconds for a food source 2000 meters away.

Direction of the food source is indicated by the direction the dancer faces during the straight portion of the dance when the bee is waggling. If she waggles while facing straight upward, than the food source may be found in the direction of the sun.



If she waggles at an angle 60 degrees to the left of upward the food source may be found 60 degrees to the left of the sun.





Similarly, if the dancer waggles 120 degrees to the right of upward, the food source may be found 210 degrees to the right of the sun. The dancer emits sounds during the waggle run that help the recruits determine direction in the darkness of the hive.

Lac culture

Lac is a resinous substance secreted by a tiny insect called *Laccifer lacca* (popular name “lac insect”)

Shellac is the purified lac usually prepared in the orange or yellow flakes

Lac or shellac is used in many ways

- Commonest use is in polishing wooden furniture. The granules are dissolved in spirit and then are applied in very thin layers on the wooden surfaces
- In sealing parcels, packets and envelopes
- As insulating material in electrical work
- In making phonograph records (now replaced by synthetic material)
- In shoe polishes
- In toys and jewellery

Utilization of lac for various purposes has been very ancient in India. A “lac palace” is described in Mahabharata, which was intended to be used for burning the Pandavas alive. The Hindi name “Lakh” or “Laksha” in Sanskrit

Lac insect

The lac insect lives on native trees in India, Burma (now called Myanmar) and Malaysia. In India it is chiefly grown on trees like " Kusum", " Palas", and "Ber".

- The minute young lac insect (also called crawler) finds a suitable branch.
- The insect inserts its beak into the plant tissue to obtain nourishment.
- It grows in size and secretes a resinous material around itself.
- The resinous material hardens on exposure to air.
- Thousands of crawlers settle side by side and the resinous secretion builds up around them and completely encases the twig.
- Most crawlers develop in about 3 months into female which occupy small cavities in the resinous mass. The females can never come out of these masses.
- Eggs develop inside the body of the female and she assumes a sac like appearance.
- The female dies, the eggs hatch, the crawlers escape and move to a nearby-uninfected part of the twig, and the process is repeated.

Extraction of Lac

- The encrusted twigs are known as **stick lac**. Such twigs are harvested.
- The stick lac is ground largely in crude mortars, and the resulting granular lac is called **seed lac**.
- The fine particles or the dust separated from the granular lac is used in making toys, bangles etc.
- The wood portion is used as fuel.
- The seed lac is washed, melted, spread out in a thin layer and dried. This is the shellac of commerce.
- It requires about 4,00,000 (4 lacs) insects to yield one kilogram of lac. The Hindi word "Lakh" for shellac possibly derives from such large number of insects required to produce lac.

- ✓ In India the lac insect is found in great abundance and millions of people directly or indirectly find livelihood in this industry.
- ✓ Lac Research Institute in Ranchi (Now in Jharkhand) conducts research on the various aspects of the lac insect, its life history, protection against enemies, etc.
- ✓ Synthetic lacquers have been produced by the modern industry, which is replacing true shellac for many purposes.

SERICULTURE

Sericulture or silk production is the breeding and management of silk worms for the commercial production of silk.

Sericulture is an important industry in Japan, China, India , Italy, France and Spain.

Brief History

Sericulture or silk production from the moth, *Bombyx mori* has a long and colourful history unknown to most people. This insect is the only living species of family Bombycidae and has been domesticated for so long that it is possible that there are no survivors in the wild any longer.

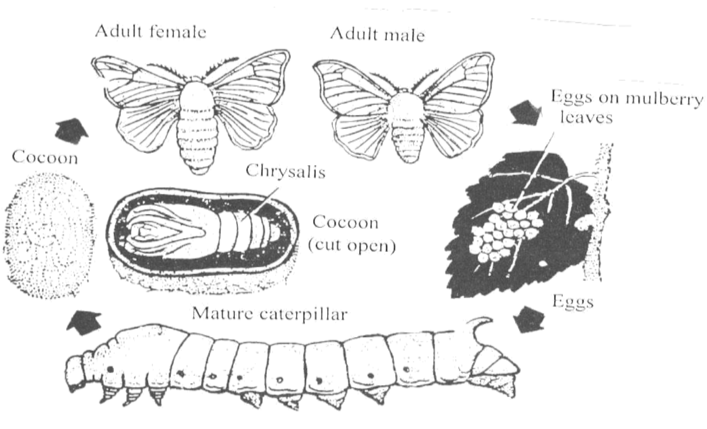
According to the Chinese records, the discovery of silk production from *B. mori* occurred about 2700 BC. It is believed that empress Si-lung-Chi was asked by emperor Huang-ti to find the cause of damaged mulberry leaves on trees in their garden. The empress found white worms eating the leaves. She noticed that they were also shiny cocoons around themselves. A cocoon dropped in her cup of teaand silky threads separated from the cocoon. Silk industry began in China where the source of silk was kept a secret for more than 2000 years. After some time, China lost their monopoly in silk production, sericulture reached Japan through Korea and then to other countries.

Sericulture has been growing in India as an agro-based industry playing a vital role in the improvement of rural economy.

Source of silk – The silkworm

The silkworm is the larva or the caterpillar of the moth *Bombyx mori* (popularly called the silk moth) the total life history of the moth (from egg to adult take 50 days. The different stages are as follows:

(i)	Egg	10 days
(ii)	Larva (4 Stages)	30 days
(iii)	Pupa (Cocoon)	10 days



Stages of life history of silk worm moth.

(i) Adult:- The adult silk moth is a creamy white moth that has a flat body and a wing expanse of about 5 cms. It takes no food and seldom attempts to fly. It lives for only 2 to 3 days. After mating, the female moth lays 300-500 eggs on leaves of the mulberry tree.

(ii) Eggs:- The eggs are round and yellowish-white, and they become grey as hatching time approaches.

(iii) Larvae

- The newly hatched larva is about 3 mm long and somewhat black in colour.
- The larvae grow in size and shed their skin (moult) four times. Each growing stage of the caterpillar consumes lot of mulberry leaves.
- The last stage full grown larva is about 7 cm long. It has a hump behind the head and a spine-like horn at the tail end.
- When full grown, the mature larva stops feeding, climbs on a twig and spins a cocoon.

(iv) Pupa

- The full grown larva pupates inside the cocoon.
- In about 10 days' time it transforms into a winged adult. The adult moth makes an opening in the cocoon and escapes through it.

The cocoon

The cocoon is formed from a secretion from two large silk glands (actually the salivary glands), which extend along the inside of the body and open through a common duct on the lower lip of the mouthparts. The larva moves the head from side to side very rapidly (about 65 times per minute) throwing out the secretion of the silk glands in the form of a thread. The secretion is a clear viscous fluid, which on exposure to the air gets hardened into the fine silk fibre.

The filament forming a cocoon is continuos and ranges in length from 700-1100 metres.

The cocoons from which moths have emerged are called pierced cocoons. These are of low value because continuous thread cannot be obtained. Pieces are removed by instruments and spun into a thread.

Rearing of silkworms

Selected healthy silk moths are allowed to mate for 4 hours. Female moth is then kept in a dark plastic bed. She lays about 400 eggs in 24 hours, the female is taken out and is crushed and examined for any disease, only the certified disease- free eggs are reared for industrial purpose. The eggs are hatched in an incubator.

The hatched larvae are kept in trays inside a rearing house at a temperature of about 20°C-25°C . These are first fed on chopped mulberry leaves. After 4-5 days fresh leaves are provided. As the larvae grow, they are transferred to fresh leaves on clean trays, when fully grown they spin cocoons.

Reeling silk

The cocoons are cooked in hot water and the silk fibre is unwound from the cocoons. This process is called reeling. The silk consists of two proteins the inner core is fibroin and an outer cover of sericin. There are four following steps for the completion of the process of reeling:

For reeling silk the cocoons are gathered about 8 days after spinning had begun.

- The cocoons are first treated by steam or dry heat to kill the insect inside. This is necessary to prevent the destruction of the continuous fibre by the emergence of the moth.
- Next, the cocoons are soaked in hot water (95° -97°C) for 10-15 minutes to soften the gum that binds the silk threads together. This process is called cooking.
- The "cooked" cocoons are kept in hot water and the loose ends of the thread are caught by hand.
- Threads from several cocoons are wound together on wheels ("charakhas") to form the reels of raw silk.
- Only about one-half of the silk of each cocoon is reelable, the remainder is used as a silk waste and formed into spun silk.
- Raw silk thus obtained is processed through several treatments to give it the final shape.

Main properties of silk

1. It is lustrous, soft and strong.
2. It is made of two proteins : the inner core is fibroin and an outer cover is sericin
3. It is hard wearing.
4. It can be dyed into several colours

Silk moth *Bombyx mori* is at present fully domesticated. It no longer exists in a wild state and it cannot survive without the human care.

Silk Producing States of India

Major Indian States producing mulberry silk are:

- Karnataka
- West Bengal
- Jammu and Kashmir

Non-mulberry "silks"

1. Tasar silk is produced by certain species of another moth *Antherea royeli*. Their larvae are reared on Arjun trees, chiefly in Bihar, Madhya Pradesh and West Bengal.

2. Muga silk is obtained from *Antherea assama* whose larvae are reared on " Som" trees in Brahmaputra Valley.
3. Eri silk is produced by the moth *Philosamia ricini* whose larvae feed on castor leaves. It is produced in Assam.

Important Point

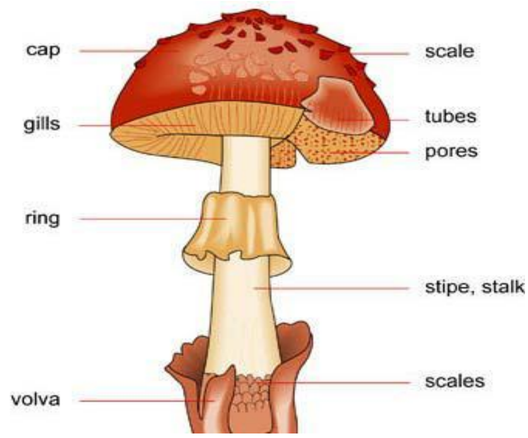
- Bee- keeping helps in three ways – provides honey, provides wax and bring about pollination of agricultural crops.
- There are four common species of honey bee - the wild *Apis dorsata* the two domestic ones *Apis indica* and *Apis mellifera* and the little bee *Apis florea*.
- A bee colony has three castes - a queen, large number of workers and the male drones (produced only for mating in the nuptial flight).
- Queen is the largest, has no wax glands, lives up to 3-4 years, and lays eggs at the rate of 800- 1500 per day.
- Queen lays two types of eggs - fertilized eggs produce females and unfertilised eggs produce male bees.

- Workers are sterile females and possess an efficient sucking proboscis, wax glands, and a sting.
- Workers live for about 35 days, and they perform different duties in different life periods.
- Workers communicate to the fellow workers of the hive about the direction and distance of the food source by means of "bee dances".
- When the hive is overpopulated the old queen with a large number of workers leaves the parent hive (swarming) and settles at some other site, and one new queen takes charge of the previous hive.
- Beekeeping is an ancient industry but the modern way is very technical. Modern hive consists of several boxes one above the other.
- A swarm is caught and is hived by either traditional method or the quicker methods.
- The plants visited by the bees are called " bee pasturage".
- Honey is a nutritious food rich in simple sugars and vitamins.
- Honey has numerous uses besides as a direct food. Beeswax is secreted by the wax glands of the workers. It has wide uses in cosmetics, varnishes, paints, candle-making.
- Lac is produced by a tiny insect *Laccifer lacca*.
- Lac has numerous uses in industry- largest being as a polishing material and in making phonograph records.
- Lac is the secretion of the lac insect, which hardens and covers the insect, making an encrustation on the twig.
- The lac on the twigs is called stick lac and after removal from the wood, and is ground into grains is called the seed lac.
- Lac is grown in the largest quantity in India in the state of Bihar.

2. MUSHROOM CULTIVATION

Mushroom is a saprophytic fungus that grows on dead and decaying organic matter. Due to the absence of chlorophyll, it is unable to synthesize its own food and hence is dependent upon the organic matter/substrate for food.

- The first record of cultivation of mushroom dates back to the reign of Louis XIV (1637-1715).
- French scientists were the first to detail record the mushroom cultivation techniques which is valid even now.
- In the same context, an article was published in Paris in 1707, following that mushrooms were cultivated in the foothills of France in 1800.
- In these regions horse dung was used (which itself got pasteurized due to high temperatures), as the substrate for spawn inoculation and mushroom production.
- Annual mushroom production has increased to 80,000 ton in 2006 from a mere 1,000 ton in 1981. Fifty percent of this is produced by marginal and small production units and the rest by industrial establishments.
- The major producers of mushrooms are Punjab (35,000 MT) Tamilnadu (15,000MT), and Andhra Pradesh (5000MT). Mushroom production of Uttarakhand alone increased from 2,640MT in 2000 to 5340MT in 2006, with Dehradun, Nainital, Haridwar and Udham Singh Nagar the major production centres.
- Button mushroom (*Agaricus bisporus*) constitutes about 90% of total production in India where that of other cultivated mushrooms viz. *Pleurotus*, *Lentinula*, *Auricularia* and *Calocybe* are very marginal.



Morphology:- Mushrooms can be defined as “a macro-fungus with distinctive fruiting bodies, epigeous or hypogeous, large enough to be seen with naked eyes and picked up by the hands”. The mushroom fruiting body may be umbrella like or of various other shapes, size and colour. Commonly it consists of a cap or pileus and a stalk or stipe but others have additional structures like veil or annulus, a cup or volva. Cap or pileus is the expanded portion of the carpophore (fruit body) which may be thick, fleshy, membranous or corky. On the underside of the pileus, gills are situated. These gills bear spores on their surface and exhibit a change in colour corresponding to that of the spores. The attachment of the gills to the stipe helps in the identification of the mushroom. On the basis of the attachment, gills are of following types:

Free gill: when the gills do not touch the stipe or only do so by a fine line.

Adnate gill: when gills are attached directly to the stem forming nearly a right angle with the stem/stipe.

Decurrent gill: when the gills extend down the stem to a greater or lesser degree.

Adnexed gill: if the attachment of the gills is only by a part of the stem to a greater or lesser degree.

Sinuate gill: when gills are near the stalk in a deep notch.

Nutritional and Medicinal Values

Proximate protein content (dry weight) of edible mushrooms as reported by different authors

Species	**Protein content (%)**	**Thiamine**	**Riboflavin**	**Niacin**
		(mg/100g air-dried)		
Volvariella volvacea	21.32	0.32	1.63	47.55
Agaricus bisporus	27.8	1.1	5.0	55.7
Pleurotus ostreatus	27.4			
Pleurotus florida	37.19	0.35	2.97	64.88
Pleurotus sajor-caju	36.94	1.16 - 4.8	-	46.108
Lentinula edodes	17.5	7.8	4.9	54.9
Auricularia auricular-judae	8.1			
Flammulina velutipes	21.9			

Medicinal Importance of Mushrooms:- The invention of the so called “wonder drug” penicillin was a landmark in the field of medicinal uses of fungi. Since then several fungi have been well recognized for their antifungal, antibacterial, antiviral, antitumour and many others such properties of pharmacological values. In the recent past a variety of medicinal preparations in form of tablets, capsules and extracts from mushrooms have been produced and marketed. Mushrooms are perhaps the only fungi deliberately and knowingly consumed by human beings and they complement and supplement the human diet with various ingredients not encountered in or deficient in food items of plant and animal origin. Besides, chemical composition makes them suitable for specific group suffering with certain physiological disorders or ailments. Mushrooms are regarded as an ultimate health food, low in calories due to presence of good amount of quality protein, iron, zinc, vitamins, minerals and dietary fibres which protects from digestive ailments and strengthening of the human immune system.

Recent investigations have proved the empirical observations of the oriental herbalists that certain mushroom possesses very useful medicinal attributes. In the 1991, the value of world medicinal crops was estimated at 8.5 billion dollars and in the same year 1.2 billion dollars are estimated to have been generated from medicinal products from mushrooms. This was based on the sale value of products from *Coriolus, Ganoderma, Lentinula, Schizophyllum* and other mushrooms.

Although the biggest use of mushroom has traditionally been for reasons of their gastronomic and nutritional appeal. There has always been interest in certain mushroom for their medicinal attributes. Production of medicinal mushroom is now a days increasing over worldwide. In the present era a variety of proprietary product based on mushroom nutriceuticals and pharmaceutical have already been produced and marketed. Various mushrooms and their metabolic extract have been reported to protect against cancer, tumor and pathogenic microorganisms. It is suggested that regular consumption of different mushroom varieties not only protects humans from heart trouble but also had medicinal potential for certain ailments.

Important Medicinal Mushrooms

Mushroom have a long history of use in traditional Chinese medicine . In fact it is estimated that in China more than 270 species of mushrooms are believed to have medicinal properties with 25% of them thoughts to have antitumour capability. Few of the edible mushrooms have also gained importance in modern medicine for their various pharmacological values.

- ***Ganoderma lucidum* (Reishi mushroom)**:
- ***Coriolus versicolour*:**
- ***Grifola frondosa* (Maitake):**
- ***Lentinula edodes* (Shiitake):**
- ***Cordyceps* species (Keera ghas):**
- ***Tremella fuciformis*:**
- ***Poria cocos***:
- ***Pleurotus* species (Oyster or Dhingri):**

LEVEL OF GROWING SYSTEM / Mushroom houses

Marginal Scale:

- **Crop Rooms (Huts) :** Made up of Sarkanda, Bamboo, Straw and Grasses
- **Crop Room/Hut size :** 30’x17’x9’
- **Containers:** Shelves or racks of bamboo and Sarkanda
- **Composting :** Long method
- **Yield :** 14-18kg/100kg compost in 8-10 weeks of harvesting

B. Small Scale:

- **Crop Rooms :** Conversion of old buildings into crop rooms or insulated crop room
- **Rooms size :** 40’x18’x12-14’ or 50’x21’x12’
- **Containers :** 3-5 tires bamboo shelves or metallic racks for 10-12kg compost
- **Composting :** Long method/Short method
- **Yield:** 15-20kg/100kg compost in 8-10 weeks of harvesting

9. Industrial Scale:

- **Crop Rooms :** Insulated and controlled

- **Room size:** 48'-100x18-27'x12'-18'
- **Containers:** Metallic racks for bags/shelves
- **Composting :** Short method
- **Yield:** 18-22kg/100kg compost in 4-6 weeks of harvesting

Spawn and Its Production:-

- Spawn is the planting material for the cultivated mushroom.
- It is merely the vegetative mycelium from a selected mushroom strain grown in a convenient medium.
- The particular strain of mushroom selected decides the type of mushroom the spawn would produce.

Mother Spawn/ Master spawn

The commonly followed method in India is as given below:-

Ten kg of wheat or sorghum grains are boiled in 15 litres water. Water is drained off over a wire netting to dry slightly. 120 g gypsum and 30 g lime ($CaCO_3$) are mixed with 10 kg of boiled grains. The gypsum prevents the sticking of grains together as clump and lime adjusts the pH. The grains are then filled into a half litre milk or glucose bottle container upto three-fourth the capacity. Bottles are plugged with non -absorbent cotton plug and are to be sterilized at 20-22 lb. psi (126 ^{0} C) for 1 ½ to 2 hours. Sterilized bottles are taken out from the autoclave while still hot and are shaken to avoid clump formation. The bottles are immediately transferred to inoculating room or chamber and allowed to cool down overnight. On the following day, bottles are inoculated with two bits of agar medium colonized with the mycelium of pure cultures raised either by tissue or spore by putting the culture bits just opposite to each other in the inner side of glass surface in the middle of the bottle. About 7 - 10 days after inoculation, bottles are to be shaken vigorously so that mycelial threads are broken and mixed with grains evenly. Three weeks after incubation, the stock culture becomes ready for further multiplication of spawn. One bottle of stock culture is sufficient to multiply in 30-40 polypropylene bags or bottles. Inoculated bottles are incubated at ambient temperature.

Commercial Spawn

The technique for raising commercial spawn is essentially the same as for master spawn except that instead of glass bottles, polypropylene bags can be used as the containers for filling grains. Inoculated bottles or polypropylene bags are incubated at ambient temperature. In two to three weeks after inoculation, spawn becomes ready for seeding the compost.

SPAWN PREPARATION

Wheat grains

↓

Boiled with water (1:1.5 w/v)

↓

Drain off excess water

↓

12g/kg grains $CaSO_4$ and 3g/kg grains $CaCO_3$

↓

Filled in bottle

↓

Sterilized at 22psi for 90 minutes

↓

Inoculation with pure culture

↓

Master spawn

↓

Commercial spawn

Qualities of a good spawn

- The spawn should be fast growing in the compost
- It should give early cropping after casing
- It should be high yielding
- It should produce better quality of mushroom

White Button Mushroom (*Agaricus bisporus*)

- Favourable season : Oct. to March (for plains of India)
- Required temp. and humidity : 14-22^{0}C and 80-85%

Cultivation process involves four major steps

1. Preparation of compost
2. Spawning of compost
3. Casing (Covering the spawned compost)
4. Cropping and crop management

Preparation of compost:

Unlike other traditional crops soil is not the appropriate substrate for mushroom cultivation. Rather, the substrate for mushroom called compost, is prepared from agro wastes like straw, stem, shoot, apices etc. with organic manure. Mushroom substrate may be simply defined as a lingo-cellulosic material that supports the growth, development and fruiting of mushroom mycelium. This compost is pasteurized by various micro-organisms and at appropriate temperature range. Essential supplement are also added/ supplemented to the compost. The whole process is termed as composting. Generally composting refers to the piling of substrates for a certain period of time and the changes due to the activities of various micro-organisms, which result in a composted substrate that is chemically and physically different from the starting material. The compost provides nutrients, minerals, vitamins and ions required for proper growth of mushroom. This compost supports the growth of only the mycelium of button mushroom and prevents that of other competitive moulds.

Methodology for compost preparation

Compost is an artificially prepared growth medium from which mushroom is able to derive important nutrients required for growth and fructification. Cemented floors are required for making good quality compost. There are two main methods for compost preparation:

(iv) Long method of composting

This is an outdoor process and takes around 28 days in its completion with a total of seven turnings. The following materials are required for long method of compost:

Wheat straw	300 Kg
Wheat bran	15 kg
Ammonium sulphate or calcium ammonium nitrate	9 kg
Super phosphate	3 kg
Muriate of Potash	3 kg
Urea	3 kg
Gypsum	30 kg
Furadan	150 g
B.H.C.	150 g

Before making compost, wheat straw is spread on cemented floor and is turned many times with water being spread at regular intervals.

Day 0: At the stage, there should be around 75% humidity content in the wheat straw, to which wheat bran, calcium ammonium nitrate, urea, murate of potash, and super phosphate are mixed thoroughly and evenly. The material is then piled 1.5m thick x1.25m high with the help of wooden rectangular block. The blocks are removed. Once the entire material has been stacked up or piled up. Water is sprayed twice or thrice to keep the substrate moist. Temperature should be in the range of 70-75^{0}C.

1st turning Day 6: On the sixth day first turning is given to the stack. The purpose of turning is that every portion of the pile should get equal amount of aeration and water. If the turnings are not given, then anaerobic condition may prevail which may lead to the formation of non-selective compost. In the stack, the central zone is fermenting at its peak and has maximum temperature rest of the portion is either not at all fermented or ferments improperly. The correct method of turning is as: Removing about 15cm of compost from the top and spread it on one side of the floor, the rest part of compost on the other side of the floor. Now turning is done by shaking the outer (top most) part and the inner part of the compost, first separately and then missing them altogether thoroughly with the help of wooden buckets.

2nd turning (Day 10): On the tenth day, again the top most part and the inner part of the compost is separated, water is sprayed on the top part. Again the two parts are piled up together in such a way that now the top part is inside and the inner part is on the top of the stack.

3rd turning (day 13)**:** it is also done in the same way as described earlier. Gypsum and furadan are mixed at this stage.

4th turning (day 16)**:** The same process of turning is followed.

5th turning (day 19)**:** The compost is turned in the same manner and B.H.C. is added.

6th turning (day 22)**:** The same process of turning is followed.

7th turning (day 25)**:** if no ammonia persists in the compost, spawning is done

2. Short method of composting

Compost prepared by short method composting is superior in production quality and the chances of infection and disease is quite low.

Ingredient:

Wheat straw	1000 kg
Chicken manure	600 kg
Urea	15 kg
Wheat bran	60 kg
Gypsum	50 kg

This method is accomplished in two phases:

Phase I- Outdoor composting

Wheat straw mixed with chicken manure is sprayed with water and a 45cm high pile is made on the fourth day and first turning is made. On 7th day, wheat bran, gypsum and urea is mixed thoroughly and piled up to 1.25-1.50 m height with a width ranging from 1.25 -1.5 m. The internal temperature of the compost should be maintained at 70-75^{0}C within 24hr. Second turning is done on this day where as third turning is done on 8th day with subsequent mixing of gypsum. On the 10th day, the compost is transferred to the pasteurization tunnel. Compost is filled in the pasteurization tunnel to a height of 7'. Filling height depends upon the size of the tunnel.

Phase II- Indoor composting

This is the pasteurization procedure which is done in a closed environment. Pasteurization has got many purposes.

If the temperature during composting has been low and the compost is heterogeneous, many parasites (nematodes, pathogens, flies and mites etc.) will survive in the compost mass, therefore, pasteurization is the best means with which these parasites can be destroyed.

To end fermentation and to convert compost into a chemical and biological state favourable to the development of the mycelium and unfavourable to moulds.

Conversion of ammonia into microbial protein.

Compost is filled in the pasteurization tunnel and as soon as the compost in the tunnel is completely filled the doors and fresh air damper are properly closed and blower is put on for recirculation of air @ 150-250 cubic metre/ 1000 kg compost/ hour. The phase II process is completed in three stages:

Pre-peak heat stage: After about 12-15 hours of compost filling, the temperature of compost starts rising and once 48-50^{0}C is obtained, it should be maintained for 36-40 hours with ventilation system. Normally such temperature is achieved by self-generation of heat by the compost mass without steam injection.

Peak heat stage: raise the temperature of compost to 57-58^{0}C by self-generation of heat from microbial activity if it is not obtained.injecting the live steam in the bulk chamber and maintain for 8 hours in order to ensure effective pasteurization. Fresh air introduced by opening of the fresh air damper to 1/6 or 1/4 of its capacity and air outlet too is opened to the same extent.

Post- peak heat stage: lower down the temperature gradually to 48-52^{0}C and maintain till no traces of ammonia are detected in compost. This may take 3-4 days in a balanced formulation. When the compost is free from ammonia, full fresh air is introduced by opening the damper to its maximum capacity and cool down the compost to around 25^{0}C which is considered as the favourable temperature for spawning. Compost when ready for spawning should possess the following characteristics:

Moisture	About 68%
Ammonia	Below 0.006%

pH	7.2-7.5
Nitrogen	Around 2.5%
Fire fangs (Actinomycetes)	Excellent growth

Spawning

The process of mixing of the spawn in the compost is known as spawning. Spawn is thoroughly mixed in the compost at the rate of 600-750 gm per 100 kg of compost (0.6 - 0.75%). The spawned compost is filled in tray or polypropylene bags covered with formalin treated newspapers. In case of bags, they should be folded at the top and covered up. After spawning, temperature and humidity of crop room should be maintained at 18-22^{o} C and 85-90%, respectively. Water should be sprayed over the covered newspapers, walls and floors of the crop room. After 12-14 days of spawning white mycelial growth is seen running the entire length of the tray/bag. This is then covered with casing soil on the surface.

Casing soil

The significance of casing soil is to maintain the moisture content and exchange of gases within the surface of the compost which helps in the proper growth of the mycelium. The pH of the casing soil should be 7.5-7.8 and must be free from any infection or disease. In our country casing soil is prepared from the following ingredients.

Two years old manure + garden soil	3:1
Two year old manure + garden soil	2:1
Two year old manure + spent compost	1:1
Two year old manure + spent compost	2:1
Two year old manure + spent compost	1:2

Pasteurization of casing soil

The casing soil is piled on cemented floor and is treated with 4% formalin solution. Thorough turning of the soil is done and it is covered with polythene sheet for the next 3- Days. Pasteurization of casing soil at 65^{0}C for 6-8 hours is found to be much more effective.

Using the casing soil

3-4cm thick layer of casing soil is being spread uniformly on the compost when the surface has been covered by white mycelium of the fungus. Formalin solution (0.5%) is then being sprayed. Temperature and humidity of the crop room should be maintained at 14-18 ^{0}C and 80-85%, respectively. Proper ventilation should be arranged with water being sprayed once or twice a day.

Harvesting of crop

Pin head initiation takes place after 10 -12 days of casing and the fruiting bodies of the mushroom can be harvested for around 50-60 days. The crops should be harvested before the gills open as this may decrease its quality and market value.

Productivity

From 100 kg compost prepared by long method of composting 14-18 kg of mushroom can be obtained. Similarly, 18-20 kg mushroom can be obtained from pasteurized compost (Short Method Compost).

Oyster mushroom (*Pleurotus sajor-caju*)

This mushroom gained importance during the last decade and now several species of Pleurotus are available for commercial production such as: *P.sajor-caju, P.florida, P.sapidus, P.eryngii, P.columbinus, P. cornucopiae, P. flabellatus. P. platypus, P. opuntiae, P. citrinopileatus.* It is now being cultivated in many countries in the subtropical and temperate zones. In China, it is known as abalone mushroom (*P. abalonus or P.cystidiosus*).

Pleurotus spp. can be grown using various agricultural waste materials. The different species of *Pleurotus* grow within a temperature range of 20^0 to 30^0C. *P. sajor-caju* can tolerate temperature up to 30^0 C although it fruits faster and produces larger mushroom at 25^0 C. *P. fossulatus* is the so-called low temperature *Pleurotus*, fruiting mostly at 12-20^0C. The tropical wastes like rice straw, wheat straw, corncobs, dried water hyacinth, sugarcane bagasse, banana leaves, cotton waste or sawdust are used for cultivation. The materials are usually soaked in water chemically sterilized with bavistin (7-10g) and formalin (120-150 ml)/ 100 litre of water for 16-18 hours. Extra water is drained off.

The process of spawn making is the same as for *Agaricus* species. *Pleurotus* spawn should be about 15 days old when mycelium has formed complete coating around the grain. The normal rate of spawning in a pasteurized substrate is 2.0-2.5% of the wet substrate. The spawning is usually done thoroughly. Before filling the substrate in polythene bags, holes of about 1 cm diameter are made at 10-15 cm distance all over the surface for free diffusion of gases and heat generated inside. The optimum temperature for growth of *Pleurotus* spp. is 23 $\pm 2^0$ C. Relative humidity in growing room should range between 85-90% during spawn- run. Usually 3 to 4 days after opening the bags, mushroom primordia begin to form. Mature mushrooms become ready for harvesting in another 2 to 3 days. An average biological efficiency (fresh weight of mushrooms harvested divided by dry substrate weight x 100) can range between 70-80% and sometimes even more. To harvest the mushrooms, they are grasped by the stalk and gently twisted and pulled. A knife should not be used. The mushrooms remain fresh for up to 3 to 6 days in a refrigerator/cool place.

Milky Mushroom (*Calocybe indica*):

Calocybe indica is an edible white summer mushroom also known as milky mushroom. It can be easily grown in the temperature range of 25-35^{0}C.

It has moderate protein content and has a good biological efficiency (60 -70%) under optimum conditions. Its sporophores have long shelf life. The major advantage is that it can be best fitted in relay cropping when no other mushroom can be grown at higher temperature. *Calocybe indica* has a very good scope for further cultivation and it can replace the other tropical mushrooms like *Pleurotus* spp. and *Volvariella* spp.

Wheat straw/paddy straw

↓

Soaked in fresh water 24 hrs

Treated with hot water

↓

2-4hrs → Remove excess water

↓

Mixed 5% wheat bran

↓

Spawning @ 4%

↓

Casing

↓

14-16 days → Primordial stage

↓

10-12 days → Harvesting

(500-600g/Kg dry wt substrate)

Paddy-straw mushroom (*Volvariella volvacea*)

Volvariella volvacea Sing., the paddy straw mushroom, or straw mushroom is the most popular mushroom in Southeast Asia. *V.diplasia* is white while *V. volvacea* is blackish. *V. bombycina* differs from the cultivated *V. volvacea* in terms of habitat as well as colour.

Cultivation of this mushroom started in China almost three hundred years ago. Several species of Volvariella have been grown for food. *V. bombycina Sing. and V.diplasia* have been cultivated in India. *Volvariella volvacea* thrives in a temperature range of 28 to 38^0 C and relative humidity of 75-85% is required. In a modified method of cultivation, bundled substrates (rice straw, banana leaves or water hyacinth), prepared in the same way as those used for beds, are soaked in water, drained, then packed (layered) in the wooden frames. Spawn is mixed in with each layer as the frame is packed or filled. The spawned substrate in the boxes may be placed in a specially built incubation room with a high temperature (35 to 38^0C) and high relative humidity (at least 75%), or it may be covered with plastic sheets and placed under shade outdoors. For spawning, the air temperature is cooled to 35^0C and the bed temperature to about 28 to 32^0 C The amount of spawn to be used is calculated at 1.5% of wet weight basis.

Major Diseases of Mushroom and their Management

IV. Green mould (*Trichoderma* spp**.)**

Symptoms:- Small blue green cushions are seen on spawned and cased trays/bags. It also grows on dead buds of mushrooms and cut stumps. Mushroom caps may turn brown top side. Green moulds enerally appear in compost, rich in carbohydrates and deficient in nitrogen. High humidity with lowpH of casing promotes its development.

V. **Brown plaster mould** (*Papulospora byssina*)

Symptoms: whitish patches on the compost or casing ultimately turning to rusty brown in colour observed on the exposed surface of compost and casing as well as on the side in bags due to moisture condensation.

Major Insect

- **White plaster moulds** (*Scopulariopsis fumicola*)
- **Inky caps** (*Coprinus* spp.)
- **Yellow mould** (*Myceliophthora lutea, Chryosporium luteum* and *Sepedonium* spp.)
- **False truffle (***Diehiliomyces microsporus***)**
- **Dry bubble disease (***Verticillium fungicola***)**
- **Mushroom Flies**
- **Sciarid flies:** (*Bradysia paupera, B. Tritici*)
- **Phorid flies:** (*Megaselia sandhui*)
- **Springtails:** (*Seira iricolor*)

3. PRINCIPLES AND ELEMENTS OF LANDSCAPE DESIGN

The systematic planning of a garden is an art. One must have a thorough knowledge of plants, soils, land topography and local environmental conditions.

Landscape:- "A landscape may be defined as any area, either big or small, on which it is possible or desirable to mould a view or a design".

Landscape gardening:- It may be described as the application of garden forms, methods and materials with a view to improve the landscape. The art of designing is known as "Landscape Architecture," although the older term "Landscape gardening" is also popular.

Important considerations of gardening:-

- A garden has to be one's own creation and not an imitation, giving due consideration to the local environment.
- Overcrowding of the plants should be avoided.
- Take advantage of natural topography while designing garden
- Perfect harmony of different components is the essence in landscape gardening.
- Before planning a design one must be sure for what purpose the garden is – utility or beauty or both.

Elements of Gardening

1. **Line:-** Line can be either fixed or moving. Examples of fixed lines are borders of paths, fences, walls, the outline of a building, the shape of a statue and the edge of a lawn. Examples of moving lines are the edge of a shadow and the outline of a fast-growing plant.
2. **Form**:- Form describes volume and mass, or the three dimensional aspects of objects that take up space. (Shape is two-dimensional) Forms can and should be viewed from any angles. When you hold a baseball, shoe, or small sculpture, you are aware of their curves, angles, indentations, extensions, and edges their forms.
3. **Mass:-** Mass is the degree of solidity of forms. Heavier, denser or darker foliage will create the effect of greater mass.
4. **Space:-** Space is the volume defined by physical boundaries such as walls, trees, shrubs, ground surface and the sky or canopy of plants above.
5. **Texture:-** Texture refers to the patterning of the components of the landscape: coarse or fine, rough or smooth etc. Texture is significant when considering scale, particularly in more intimate, smaller areas. There is texture in plants, wood, stone, gravel, and even in water as the wind blows over its surface.
6. **Colour:-** Colour can be used for harmony or contrast. Generally (but not always) designers use contrasting colours sparingly. In general pale, cool colours (blue, green, white, silver and pastel shades) create a relaxing atmosphere in the garden, while hot, vibrant colours (reds, yellows, orange, bright pink) demand attention and subconsciously encourage activity.

7. **Tone:-** Tone is the relationship between colour, light and texture.

Principles of Landscape Gardening

A. **Balance:-** Balance is a psychological sense of equilibrium. As a design principle, balance places the parts of a visual in an aesthetically pleasing arrangement. In visual images, balance is formal when both sides are symmetrical in terms of arrangement. Balance is informal when sides are not exactly symmetrical, but the resulting image is still balanced. Informal balance is more dynamic than formal balance and normally keeps the learner's attention focused on the visual message. There are three main types of balance, horizontal balance, vertical balance, radial balance.

B. **Proportion:-** Proportion refers to the relative size and scale of the various elements in a design. The issue is the relationship between objects, or parts, of a whole. This means that it is necessary to discuss proportion in terms of the context or standard used to determine proportions.

C. **Perspective:-** Perspective is created through the arrangement of objects in two-dimensional space to look like they appear in real life. Perspective is a learned meaning of the relationship between different objects seen in space.

Is the dark rectangle in front of a circle, or beside a semi-circle? Perspective adds realism to a visual image. The size of a rectangle means little until another object gives it the size of a desk, or the size of a building. Perspective can be used to draw the audience into a visual. Perception can be achieved through the use of relative sizes of objects, overlapping objects, and blurring or sharpening objects.

D. **Emphasis:-** Emphasis is used by artists to create dominance and focus in their work. Artists can emphasize color, value, shapes, or other art elements to achieve dominance. Various kinds of contrast can be used to emphasize a center of interest.

E. **Movement:-** The way the artist leads the eye in, around, and through a composition. The path the eye follows. Motion or movement in a visual image occurs when objects seem to be moving in a visual image. Movement in a visual image comes from the kinds of shapes, forms, lines, and curves that are used.

F. Pattern:- Pattern uses the art elements in planned or random repetition to enhance surfaces or paintings or sculptures. Patterns often occur in nature, and artists use similar repeated motifs to create pattern in their work. Pattern increases visual excitement by enriching surface interest.

G. Repetition:- Repetition works with pattern to make the artwork seem active. The repetition of elements of design creates unity within the artwork.

H. Rhythm:- Rhythm is the repetition of visual movement of the elements-colors, shapes, lines, values, forms, spaces, and textures. Variety is essential to keep rhythms exciting and active, and to avoid monotony. Movement and rhythm work together to create the visual equivalent of a musical beat.

I. Variety:- Variety provides contrast to harmony and unity. Variety consists of the differences in objects that add interest to a visual image. Variety can be achieved by using opposites or strong contrasts. Changing the size, point of view, and angle of a single object can add variety and interest to a visual image.

Breaking a repeating pattern can enliven a visual image.

J. Harmony:- Harmony in visual design means all parts of the visual image relate to and complement each other. Harmony pulls the pieces of a visual image together. Harmony can be achieved through repetition and rhythm. Repetition reemphasizes visual units, connecting parts and creating an area of attention. Rhythm is the flow depicted in a visual. Rhythm helps direct eye movement.

Patterns or shapes can help achieve harmony. By repeating patterns in an interesting arrangement, the overall visual image comes together.

K. Unity:- Unity means the harmony of the whole composition. The parts of a composition made to work together as a total visual theme. Unity is the relationship among the elements of a visual that helps all the elements function together. Unity gives a sense of oneness to a visual image. In other words, the words and the images work together to create meaning.

L. Contrast:- Contrast is in opposition to harmony and should not be overdone. Occasional contrasts are used to create an eye catching feature in a garden; for example, contrasting foliage texture, colour or form provides a focal point in the garden.

Lawn

There are four aspects of turf-grass establishment: selecting a turf-grass that is adapted for that particular area; preparing the soil for planting; planting, which may include seeding, sodding, plugging or sprigging; and care and maintenance of the newly planted lawn to ensure successful establishment.

Turf-grass Selection:- Proper turf-grass selection is one of the most important factors in the successful establishment of a home lawn. Not all species and cultivars will perform equally when placed in the widely differing geographical areas and local climates found in South Carolina. The turf-grass you select should be adapted to your area and meet the level of lawn quality you desire.

Soil Preparation:- The key to establishing a lawn successfully is proper soil preparation. This soil preparation is the same for planting seed, sprigs, stolons or sod.

Soil Test: Soil testing will determine whether the soil pH and nutrient (phosphorus, potassium, calcium and magnesium) levels are in a range that favour turf-grass growth. The soil test report will indicate needed amounts of fertilizer and/or lime.

Clean & Rough Grade: Remove all debris from the location to be planted. This includes rocks, bottles, large roots and old tree trunks. If extensive grading is needed, remove the topsoil and stockpile it for replacement after the rough grade is established.

The subsurface may become compacted during rough grading, especially if the ground is wet. This compacted layer must be broken up. A spring-tooth harrow works well on lightly compacted soils; a small rototiller may be needed for more heavily compacted sites.

Deep Tillage: Rototilling loosens compacted soil and improves the speed and depth of rooting. A tractor-mounted or self-propelled tiller will adequately till the soil. Take care not to destroy the existing trees in the lawn. Cutting too many tree roots during soil tillage can severely damage or kill a tree. Trees can also be suffocated by deeply covering the roots with soil. If additional soil is necessary at a tree base, construct a "tree well."

Replace the Topsoil: Once the subsurface is established, return the topsoil and spread uniformly over the entire area. Allow for at least 6 to 8 inches of depth after the soil has settled. This means placing about 8 to 10 inches of topsoil over the subsurface. Improve the soil by adding organic matter. This improves water retention in sandy soils and drainage in clay soils and reduces fertilizer leaching.

Fertilization & Liming: Apply the amounts of fertilizer and lime recommended by the soil test and work into the upper 4 to 6 inches of soil. If the soil test indicates a high pH, the addition of sulphur or aluminium sulphate can be tilled into the soil to lower the pH into the correct soil pH range. In the absence of a soil test, a general recommendation is to use a slow-release, "starter-type" fertilizer specially formulated to contain the higher amounts of phosphate that are required by turf-grass seedlings during establishment. Apply 1½ to 2 pound of actual nitrogen per 1,000 square feet prior to planting. Examples and amounts to use of slow-release starter fertilizers are:

- Lesco Professional Starter Fertilizer (18-24-12; use 8 to 11 pounds of fertilizer per 1000 square feet),
- Sta-Green Lawn Starter Fertilizer (18-24-6; use 8 to 11 pounds of fertilizer per 1000 square feet),
- Pennington Lawn Starter Fertilizer (18-24-6; use 8 to 11 pounds of fertilizer per 1000 square feet),
- Ferti-lome New Lawn Starter (9-13-7; use 17 to 22 pounds of fertilizer per 1000 square feet),
- Scott's Turf Builder Starter Fertilizer (24-25-4; use 8 to 10 pounds of fertilizer per 1000 square feet).

The slow-release fertilizers should be tilled into the soil, but they can be applied at planting. The nitrogen in these fertilizers will typically last 2 months.

Some of the coastal soils may naturally contain very high amounts of phosphorus, such as in Horry, Georgetown, Charleston and Beaufort county soils. In lieu of a regular starter fertilizer, which is high in phosphorus, substitute a slow-release centipede lawn fertilizer (15-0-15 with iron) to incorporate into the soil at the rate of 10 - 13 pounds fertilizer per 1000 square feet of all lawn grasses. Because of the greater sensitivity of centipedegrass to high amounts of phosphorus in the soil, it is very important to have the soil tested. If the soil test reveals levels of phosphorus that are medium or above, use a slow-release 15-0-15 as the starter fertilizer at planting.

If a water-soluble, quick- release source of nitrogen is used, do not apply and mix in more than 1 pound of actual nitrogen per 1,000 square feet. An example and amount of a fast -release, "starter-type" of fertilizer is 20 pounds of a farm grade 5-10-10 fertilizer per 1,000 square feet of lawn. If a 5-10-10 is unavailable, use 10 pounds of 10-10-10 per 1000 square feet of lawn. The fast -release fertilizers should be tilled into the soil pre-plant, but could be applied after grass seed has germinated. The nitrogen in most quick-release farm fertilizers will typically last one month.

Final Grading: After the fertilizer and lime or sulfur have been worked into the soil, firm the soil by rolling with a water ballast roller before seeding, sodding and plugging. The best soil for seeding has a granular texture with small clods of soil varying from one-eighth inch to three-quarters inch in size. However, if the area is to be sprigged the soil should remain loose in the upper 2 to 3 inches so a portion of each sprig can be set (pushed) into the soil. Once the soil is properly prepared, it is time to plant.

Seeding:- Assuming that adequate soil preparation was done, the appropriate turfgrass species or blend was chosen and a high-quality seed lot was obtained, the three main factors affecting turfgrass establishment from seed are: planting procedures, mulching and post-germination care.

Successful establishment from seed depends on purchasing top-quality seed. Law requires that each container of seed have a tag listing the turf-grass species and cultivar, purity, percent germination and weed content. Purity indicates the amount (as a percentage) of the desired seed as well as other seed and inert matter. Germination percentage tells the amount of seed expected to germinate under optimum conditions. The quantity of weed seeds is also listed. Try to purchase seed that has a purity of 90 percent or higher and a germination of 85 percent or higher.

Many seeding methods are used, ranging from planting by hand to using mechanical equipment for large turf areas. Evenness of seed distribution is important from the standpoint of overall uniformity. The seedbed should be well-prepared and leveled.

Rake the entire area with a garden rake. Apply the seed mechanically either with a drop-type or rotary spreader. Mechanical seeders provide a more uniform distribution of seed than hand seeding. For best distribution of seed, sow one-half the required amount in one direction and apply the remainder at right angles to the first seeding. For very small seed like centipedegrass or bermudagrass, it may be helpful to mix the seed with a carrier such as corn meal, grits or an organic fertilizer to distribute the seed evenly.

With a rake, mix the grass seed with the top one-quarter inch of soil. Then roll the seedbed with a light or empty water-ballast roller to ensure good seed-to-soil contact. Mulch the seedbed to prevent soil erosion, retain moisture and prevent crusting of the soil surface. The most commonly used mulch is straw. However, it is important to use weed-free straw. One bale of straw (60 to 80 pounds) will cover about 1,000 square feet. Straw can be removed when the turf reaches a height of 1 to 1½ inches or can be left to decompose if it is not spread too thickly.

Peat moss and aged sawdust do not make good mulches for seeded lawns. These materials compete with the seed for water and are slow to decay.

Water the lawn as soon as possible after seeding. Watering with a fine spray will help seed to germinate, but be sure to prevent washing or puddling.

Care of the Newly Seeded Lawn

Irrigation: Proper watering is the most critical step in establishing turfgrasses from seed. Apply water frequently so that the soil is moist, but not excessively wet. Supplying water two or three times a day in small quantities for about two to three weeks will ensure adequate moisture for germination. If the surface of the soil is allowed to dry out at any time after the seeds have begun to swell and before roots have developed, many of the seedlings will die. As the seedlings mature and the root system develops, the frequency of waterings can be decreased, but the volume should be increased, so that the entire root zone is moistened, not just the soil surface.

Care after Germination of Seed

During the establishment phase, a number of practices can be employed to help ensure a uniform, dense turf. A combination of mulching and irrigation is the key factor in successful turfgrass establishment. If a straw or hay mulch is used, be sure to monitor the grass seedlings for shading. If the new seedlings show a yellowing, lightly rake away some of the mulch.

Mowing:- Begin normal mowing practices when the turfgrass seedlings reach a height one-third higher than the normal mowing height. It is important to maintain a sharp cutting blade to avoid pulling these seedlings out of the soil.

Fertilization: A light application of nitrogen fertilizer made when the seedlings are between 1½ and 2 inches tall will enhance the establishment rate substantially. Apply about one-half pound of actual nitrogen per 1,000 square feet watered into the soil. Avoid excessively high nitrogen fertilization.

Irrigation: The surface of the soil where seeds are germinating and seedling growth occurs should be moist at all times. The goal is to water often enough to keep the seedbed moist but not saturated, until the plants can develop sufficient root systems to take advantage of deeper and less frequent watering. Soils that have not been mulched will tend to dry out quickly. Less irrigation will be needed if mulch was used. The quantity of water applied will be small and should be maintained for at least three weeks following planting. As the turf-grass matures, reduce irrigation to a maintenance level to promote a deep root system.

Weed Control: Timing of weed control practices is also critically important once seeds have germinated. Most herbicides are somewhat toxic to newly germinated turf-grass plants. Delay post-emergence applications of a herbicide for weed control as long as possible after seeding. Follow recommendations found on pesticide labels closely as far as timing of application and planting. Diligent care of the young lawn during the first two or three months is important for its overall success.

Vegetative Planting:- Vegetative planting is simply the transplanting of large or small pieces of grass. Solid sodding covers the entire seedbed with vegetation. Spot sodding, plugging, sprigging or stolonizing refer to the planting of pieces of sod or individual stems or underground runners called stolons or rhizomes.

Most warm-season turf-grasses are established by planting vegetative plant parts. Exceptions to this include centipedegrass, carpetgrass, common bermudagrass and Japanese lawngrass (*Zoysia japonica*), which can be established from seed.

Sodding: Sodding is more expensive than sprigging or plugging, but it produces a so-called "instant" lawn. It is recommended where quick cover is desired for aesthetic reasons or to prevent soil erosion. Establishment procedures for sod include soil preparation, obtaining sod of high quality, transplanting and postplanting care.

Soil Preparation: Soil preparation for sodding is identical to that for seeding.

Sod Quality: Before buying the sod, inspect it carefully for weeds, diseases and insects. Store the sod in a cool, shady place until used, but do not store for a long period. Purchase the right amount; try to install it as soon as it is delivered.

Sod Transplanting:- The primary objective in sod transplanting is to achieve as quick a rooting into the underlying soil as possible. Factors that influence quick rooting include: proper soil preparation, adequate soil moisture in the underlying soil and transplanting techniques that will minimize sod drying.

Install cool-season grass sod anytime during the year as long as the soil is not frozen. If done in the fall, transplanting should be completed early enough to allow root growth into the underlying soil before cold weather arrives. Winter sodding is done when conditions for root growth are not favorable. The grass may or may not survive the winter depending on temperatures.

Dampen the soil just prior to laying the sod to avoid placing the turf roots in contact with excessively dry and hot soil. To reduce the need for short pieces when installing sod, it is generally best to establish a straight line lengthwise through the lawn area. The sod can then be laid on either side of the line with the ends staggered in a checkerboard fashion. A sharpened concrete trowel is handy for cutting pieces, forcing the sod tight but not overlapping and leveling small depressions.

Do not stretch the sod while laying. The sod will shrink upon drying and cause voids. Stagger lateral joints to promote more uniform growth and strength. On steep slopes, lay the sod across the angle of the slope; it may be necessary to peg the sod to the soil with stakes to keep it from sliding. Immediately after the sod has been transplanted, it is important to roll or tamp it. This will eliminate any air spaces between the soil and the sod. Roll perpendicular to the direction the sod was laid.

Water newly transplanted sod immediately to wet the soil below to a 3-inch depth to enhance rooting. Do not let the soil dry out until a good union between the sod and soil surface has been achieved. Light, frequent applications of soil topdressing will help to smooth out the lawn surface.

Care after Transplanting Sod:- Irrigate newly transplanted sod to a depth of 4 inches immediately after transplanting to promote deep root growth. In the absence of adequate rainfall, water daily or as often as necessary during the first week and in sufficient quantities to maintain moist soil to a depth of at least 4 inches. The sod should then be watered lightly during midday hours until rooting into the underlying soil has taken place. Deeper, thorough watering can then be done as the roots begin to penetrate the soil.

Do not mow until the turf-grass sod is firmly rooted and securely in place. The mowing height and frequency on newly sodded areas should be the same as normally practiced on established turfs. Fertilization of the sod after transplanting should not be needed since the grass should have been grown under optimum conditions and fertilizer should have been incorporated into the soil before transplanting. Start a fertility program after the sod has established a good root system.

Sprigging: Sprigging is the planting of stolons or rhizomes in furrows or small holes. A sprig is an individual stem or piece of stem of grass without any adhering soil. A suitable sprig should have two to four nodes from which roots can develop. Soil preparation for sprigging should be the same as for the other methods of planting.

To plant sprigs, dig furrows 8 to 12 inches apart and place the sprigs at a 1- to 2-inch depth (use the shallower depth if adequate moisture is available) every 4 to 6 inches in the furrows. The closer the sprigs are, the faster the grass will cover the soil.

After placing the sprigs in the furrow, cover a part of the sprig with soil and firm. The foliage should be left exposed at the soil surface. Another method is to place the sprigs on the soil surface at the desired interval end-to-end, about 6 inches apart, and then press one end of the sprig into the soil with a notched stick or blunt piece of metal like a dull shovel. A portion of the sprig should be left above ground exposed to light. Regardless of the planting method, each sprig should be tamped or rolled firmly into the soil. Water after planting. Since the sprigs are planted at a shallow depth, they are very prone to drying out. Light, frequent waterings are necessary until roots become well-established. Watering lightly once or twice daily will be required for several weeks after planting.

Stolonizing is the broadcasting of stolons on the soil surface and covering by topdressing or pressing into the soil. Stolonizing requires more planting material but produces a quicker cover than sprigs.

Care after Sprigging:- It is extremely important to maintain a moist surface during the initial establishment from sprigs. If practical, topdress newly planted sprigs at regular intervals.

Plugging:- The planting of 2- to 4-inch diameter square, circular or block-shaped pieces of sod at regular intervals is called plugging. Three to 10 times as much planting material is necessary for plugging as sprigging. The most common turfgrasses that are started by the use of plugs are St. Augustinegrass, zoysiagrass and centipedegrass. These plugs are planted into prepared soil on 6- to 12-inch centers. The closer the plugs are planted together, the faster the sod will cover. However, the closer the plugs are planted together, the more sod it will take to provide plugs to cover the lawn area.

Prior to plugging, prepare the soil the same as that for seeding or sodding. Plugging can be done by special machines designed to plant plugs or by hand on smaller areas. Timing of plug transplanting for warm-season turf-grasses should take place in the late spring or early summer. This will give the turf optimum growing conditions to establish. After the plugs have been transplanted, the soil should be rolled to ensure good plant-to-soil contact. Irrigation should follow the same guidelines as for sodding.

Care after Plugging: Post-plugging care involves mowing at the height and frequency required for that particular turf-grass. A fertilizer application made three to four weeks after plugging enhances the establishment rate. Proper irrigation procedures will also enhance establishment of a lawn through plugging.

Important lawn grass species

Botanical Name	Common name	Texture	Situation
Cynodon dactylon	Hariyali (or) Arugu (or) Doob grass	Medium fine	Suitable for open sunny location; drought resistant
Stenotaphrum secundatum	St. Augustine grass or Buffalo grass	Coarse texture	Suitable for shady situation; requires frequent watering
Sporobolus	Chain grass (or) Upparugu	Fine	Suitable for saline soils and open sunny

tremulus			locations
Poa annua	Annual blue grass	Medium fine	Suitable for acid soils and suitable for higher elevations
Pennisetum clandestinum	Kikuyu grass	Rough	Grow well in acids soils, suitable for higher elevations.
Zoisia japonica	Japan grass	Coarse	Suitable for poor sandy soil; open sunny situation, slow in growth
Z. matrella	Manila grass	Medium	Suitable for open sunny situation
Z. tenuifolia	Korean grass or velvet grass or carpet grass	Fine	Suitable for open sunny situation
Cynodon sp.	Bermuda grass (or) Hyderabad grass	Fine	Suitable for open sunny situation, needs mowing
Cynodon sp.	Dwarf Bermuda	Medium	Suitable for open sunny situation
Festuca sp.	Fescue grass	Coarse	Shade tolerant, survive on inferior soils
Paspalum vaginatum	Paspalum grass	Medium	Suitable for open sunny situation

Avenue Gardening

Avenue Gardening:- In landscaping, an **avenue**, or **allée**, is traditionally a straight path or road with a line of trees or large shrubs running along each side, which is used, as its French source *venir* ("to come") indicates, to emphasize the "coming to," or *arrival* at a landscape or architectural feature. In most cases, the trees planted in an avenue will be all of the same species or cultivar, so as to give uniform appearance along the full length of the avenue. The French term *allée* is used for avenues planted in parks and landscape gardens, as well as boulevards such as the *Grande Allée* in Quebec City, Canada, Bologna Alley in Zagreb and *Karl-Marx-Allee* in Berlin.

History:- The avenue is one of the oldest ideas in the history of gardens. An avenue of sphinxes still leads to the tomb of the pharaohHatshepsut (died 1458 BCE); see the entry Sphinx. Avenues similarly defined by guardian stone lions lead to the Ming tombs in China. British archaeologists have adopted highly specific criteria for "avenues" within the context of British archaeology.

In order to enhance the approach to mansions or manor houses, avenues were planted along the entrance drive. Sometimes the avenues are in double rows on each side of a road. Trees preferred for alleys were selected for their height and speed of growth, such as poplar, beech, lime, and horse chestnut.[1] In the American antebellum era South, the southern live oak was typically used, because the trees created a beautiful shade canopy.

Sometimes tree avenues were designed to direct the eye toward some distinctive architectural building or feature, such as a chapels, gazebos, or architectural follies.[2]

In Garden à la française Baroque landscape design, avenues of trees that were centered upon the dwelling radiated across the landscape. See the avenues in the Gardens of Versailles or Het Loo. Other late 17th-century French and Dutch landscapes, in that intensely ordered and flat terrain, fell naturally into avenues; Meindert Hobbema, in *The Avenue at Middelharnis* (1689) presents such an avenue in farming country, neatly flanked at regular intervals by rows of young trees that have been rigorously limbed up; his central vanishing point mimics the avenue's propensity to draw the spectator forwards along it.

Tree suitable for Avenue

Acer saccharum (Sugar Maple)

Quercus alba (White Oak)

Quercus coccinea (Scarlet Oak)

Quercus rubra (Red Oak)

*Quercus velutina (*Black Oak)

Tilia euchlora (Crimean Linden)

Tilia tomentosa (Silver Linden)

Tilia vulgaris (Common Linden)

Ulmus americana (American Elm)

Ulmus glabra (Scotch Elm)

Acer platanoides (Norway Maple)

Ailanthus glandulosa (Tree of Heaven)

Celtis occidentalis (Nettle Tree)

Fraxinus spp (Ash Tree)

Ginkgo biloba (Maidenhair Tree)

Liquidambar styraciflua (Sweet Gum)

Liriodendron tulipifera (Tulip Tree)

Platanus orientalis (Oriental Plane)

Phellodendron amurense (Chinese Cork Tree)

Quercus palustris (Pin Oak)

Ulmus campestris (English Elm)

TYPES OF GARDEN

Formal and informal gardens:- Man's eternal desire is to make his living place like that of a paradise. The geometrical design of the earlier dwellings when man came out of caves lead to orderliness as well as provided life security. But it lacked the raw nature around him inside the dwelling.

FORMAL STYLE

The gardens of Greece and Rome assured an emotional security though their Formal style. The Persian, Moorish gardens of Spain and Moghul gardens were also of the same kind and were strictly formal, symmetrical and geometrical resembling a carpet.

- The Italian renaissance garden was having intricate geometric designs, sheared trees, trimmed hedges and edges to create formality.
- The impact of formalism influenced the French and British gardens also in the form of parierre, the much divided flower beds.
- The Moorish garden of Spain also had the impact of Moghul's architecture and they were formal and geometrical though Moorish gardens were exclusively meant to beautify patios of large mansions.

The key features of formal design are

- Plan is made on the paper and land is selected accordingly.
- The plan is symmetrical with square, rectangular and roads cut at right angles.
- It had a sort of enclosure or boundary.
- Flower beds also have geometric designs as in carpets.
- The arrangement of trees and shrubs are necessarily geometrical and kept in shape by trimming and training.
- Other features like fountains, water pools, cascades, etc. are used for further attraction.

Demerits

- Formal gardens have no 'secrets' and the element of surprise is lost.
- However, attractive focal points at terminal and intersecting points of paths and roads are provided to make the formal garden effective.
- Present day home gardens are laid out in formal design only at the frontage.

INFORMAL STYLE

- Hindu, Buddhist and Japanese garden laid no emphasis on formality.
- Woodlands (vanams) and running water (streams and rivers) was the main feature around which the garden was created in natural way.
- Brindavan of Lord Krishna was a woodland.

- Every temple was provided with irregular shaped lotus tanks. (Latter on such tanks was given masonry boundary either rectangular or square).
- Japanese developed an intensely national and naturalistic style of its own. It is in Japanese garden, the asymmetric balance has been perfected.
- The impact of industrial climate drove the Britishers to opt for natural gardens latter

The further the man is isolated from nature (due to industrial revolution) the deep is the longing to go back to nature. The industrialized cities became concrete jungles with no flavour and aroma of nature and there was emptiness in human life. To avert this, natural gardens was given impetus.

- The nature's projection of mountains, oceans, rivers and lakes on a larger canvas of earth's surface is informal with all its grandeur. Such grandeur is mimicked in informal gardens omitting the untamed, disastrous and violent side of nature.
- Lanchlot 'capability' Brown (1716-83): She emphasized the use of coloured flower and foliage, tree form, etc. in natural style.
- The cottage gardens of UK had the utility with fruits, vegetable and herb plants as well as the beauty that spans from its harmony with surrounding rural scenery.

Key feature of informal style/natural style

- This style reflects naturalistic effect of total view and represents natural beauty.
- It is contrast to formal style.
- Plan is asymmetrical according to the land available for making the garden.
- Smooth curvaceous out lines are more appropriate.
- Water bodies are more irregular in shape.
- Hillock are made, water falls provided, lakes and islands, cascades, rocks, shola and a rustic hutment are provided to create rural effect. Appropriately grouped plants provide living quality and they are not trimmed.

FREE STYLE OF GARDENING

This style combines the good points of both formal and informal style of gardening. Rose garden of Ludhiana is an example of this style of gardening.

4. Bio-pesticide and It's Formulation

Introduction

Bio pesticide is a formulation made from naturally occurring substances that controls pests by nontoxic mechanisms and in eco-friendly manner. Biopesticides may be derived from animals (e.g. nematodes), plants (*Chrysanthemum*, *Azadirachta*) and micro-organisms (e.g. *Bacillus thuringiensis*, *Trichoderma*, *nucleopolyhedrosis virus*), and include living organisms (natural enemies) etc.

However, biopesticides are generally less toxic to the user and are non-target organisms, making them desirable and sustainable tools for disease management.

Advantages of bio pesticides

- Inherently less harmful and less environmental load,
- Designed to affect only one specific pest or, in some cases, a few target organisms,
- Often effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems.
- When used as a component of Integrated Pest Management (IPM) programs, bio pesticides can contribute greatly.

Types of bio pesticides

- Microbial pesticides
- Plant-incorporated-protectants (PIPs)
- Biochemical pesticides
- Botanical pesticides
- Biotic agents (parasitoids and predators)

Microbial Pesticides:-

- Microbial pesticides are composed of microscopic living organisms (viruses, bacteria, fungi, protozoa, or nematodes) or toxin produced by these organisms.
- Applied as conventional insecticidal sprays, dusts, or granules.
- Their greatest strength is their specificity as most are essentially nontoxic and non-pathogenic to animals and humans.
- Microbial pesticides includes insecticides, fungicides, herbicides and growth regulators of microbial origin.

Some of the important microbial pesticides

1. ***Bacillus thuringiensis***
    - Bacillus thuringiensis (Bt) is a unique bacterium in that it shares a common place with a number of chemical compounds which are used commercially to control insects important to agriculture and public health.
    - Discovered in Japan in early 20th century and first become a commercial product in France in 1938.
    - Control lepidopterous pests like American bollworm in cotton and stem borers in rice.

- When ingested by pest larvae, Bt releases toxins which damage the mid gut of the pest, eventually killing it.
- Main sources for the production of Bt preparations are the strains of the subspecies kurstaki, galeriae and dendrolimus

2. ***Agrobacterium radiobacter*** (Agrocin):-
   - *Agrobacterium radiobacter* is a gram negative bacillus found in soil containing organic material (rhizosphere). It is a saprophytic organism, meaning it uses dead plant material for nutrients.
   - *Agrobacterium radiobacter* is used to treat roots during transplanting, that checks crown gall.
   - Crown gall is a disease in peaches, grapevine, roses and various plants caused by soil borne pathogen *Agrobacterium tumefaciensm*.
   - The effective strains of *A. radiobacter* possess two important features:
     - ✓ They are able to colonize host roots to a higher population density.
     - ✓ They produce an antibiotic, agrocin that is toxic to *A. tumefaciens*.
3. ***Pseudomonas fluorescens* (Phenazine)**
   - *Pseudomonas fluorescens* is an obligate aerobe, gram negative bacillus. These bacteria are able to inhabit many environments, including: plants, soil, and water surfaces.
   - This bacteria is used to control damping off caused by *Pythium sp., Rhizoctonia solani, Gaeumannomyces graminis.*
   - It has ability to grow quickly in the rhizosphere
4. ***Trichoderma***
   - Trichoderma is a very effective biological mean for plant disease management especially the soil born.
   - It is a free-living fungus which is common in soil and root ecosystems. It is highly interactive in root, soil and foliar environments.
   - It reduces growth, survival or infections caused by pathogens by different mechanisms like competition, antibiosis, mycoparasitism, hyphal interactions, and enzyme secretion.
   - Trichoderma is a fungicide effective against soil borne diseases such as root rot.
   - This is also used against *Necteia galligena*, that causes silver leaf disease of fruit trees by entering through pruning wounds.
5. ***Metarizium anisopliae***
   - Metarhizium anisopliae is an entomopathogenic fungus that infects insects that come in contact with it.
   - Once the fungus spores attach to the surface of the insect, germinate and begin to grow, they then penetrate the exoskeleton of the insect and grow very rapidly inside the insect causing the insect to die.
   - Other insects that come in contact with infected insects also become infected with the fungus.
   - It infects spittlegbugs, rhinoceros beetles.
6. ***Beauveria bassiana***
   - *Beauveria bassiana* is a naturally occurring entomo-pathogenic fungus in most part of the world.

- The spore of this fungus when comes in contact with the cuticle (skin) of the target insect pest they germinate and grow directly through the cuticle to the inner body of the host.
- The fungus proliferates throughout the insect's body, draining the insect of nutrients, eventually killing it in about 48-72 hours after spray.
- Controls Colorado potato beetle.

7. ***Verticillum lecanii***
   - *Beauveria bassiana* is a naturally occurring entomo-pathogenic fungus in most part of the world.
   - The spore of this fungus when comes in contact with the cuticle (skin) of the target insect pest they germinate and grow directly through the cuticle to the inner body of the host.
   - The fungus proliferates throughout the insect's body, draining the insect of nutrients, eventually killing it in about 48-72 hours after spray.
   - Controls aphids and whiteflies.
8. ***Nomuraea riley***
   Controls soybean caterpillars.
9. ***Baculoviruses(Bvs)***
   Control lepidopterous and hymenopterous pests.
   Rod shaped, circular double stranded super coiled DNA.

Plant-incorporated-protectants (PIPs):- Consistent with the Coordinated Framework for Regulation of Biotechnology issued by the U.S. Office of Science and Technology Policy in 1986 (51 FR 23302) genetically modified (GM) crops with pesticidal traits fall under the oversight of EPA, the U.S. Department of Agriculture, and the U.S. Food and Drug Administration. EPA's oversight focuses on the pesticidal substance produced (e.g., Bt Cry proteins) and the genetic material necessary for its production in the plant (e.g., Cry genes). EPA calls this unique class of biotechnology-based pesticides plant-incorporated protectants (PIPs). PIPs are pesticidal substances that plants produce and the genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. EPA regulates the protein and its genetic material, but not the plant itself.

Botanical pesticides:- These are naturally occurring plant material that may be crude preparation of the plant parts ground to produce a dust or powder that can be used in full strength or dilute form in a carrier such as clay, talc or diatomaceous earth. "Azadirachtin" effects the reproductive and digestive procees of pest. Several plant based insecticides as nicotinoids, natural pyrethrins, rotenoids, neem products etc are used.

Biochemical pesticides

They are naturally occurring substance to control pest by non-toxic mechanisms. Biochemical pesticides include substances as insect sex pheromones that interfere with mating that attract insect pest to traps.

A. **Semiochemicals:-** These are chemicals emitted by plants or animals that modify the behaviour of receptor organisms of like or different kinds. The terms commonly used for various semiochemicals (chemical signals) include pheromones (acting between individuals within a species) and allelochemicals (acting between individuals of different species). Allelochemicals can be categorized into allomones (advantage for sender), kairomones (advantage for receiver), synomones (advantage for both) and apneumones (from non-living sources). Pheromones are substances emitted by a member of one species that modify the behaviour of others within the same species. Allomones are chemicals emitted by one species that modify the behaviour of a different species to the benefit of the emitting species. Kairomones are chemicals emitted by one species that modify the behaviour of a different species to the benefit of the receptor species. Semiochemicals determine insect life situations such as feeding, mating and egg-laying (ovipositing). Semiochemicals are thus potential agents for selective control of pest insects (for definitions of terms used for various chemical signals). Biological control with pheromones or kairomones can be used for detection and monitoring of insect populations. Monitoring is important for the efficient use of conventional or unconventional insecticides. Mating disruption by use of pheromones is a promising and in many cases, it is a successful strategy for pest control (confusion strategy). The use of semiochemicals as feeding deterrents is another strategy. The most common strategy for control by the use of semiochemicals is to attract, trap and kill the pest insects.

B. **Hormones:-** These are biochemical agents synthesized in one part of an organism and translocated to another where they have controlling, behavioral, or regulating effects. New approaches to the development of insect control agents have been revealed through the description of natural and synthetic compounds capable of interfering with the processes of development and reproduction of the target insects. The information on novel insecticides that mimic the action of two insect growth and developmental hormone classes is the ecdysteroids and the juvenile hormones. Neuropeptide structures, their biogenesis, action and metabolism also offer the opportunity to exploit novel control agents.

C. **Plant Extracts:-** Plants are infact, natural laboratories in which a great number of chemicals are biosynthesized. Many plants have developed natural and biochemical mechanisms to defend themselves from weed competition and animal, insect and fungal attacks. Some of these chemicals discourage feeding by insects and other herbivores. Others provide protection or even immunity from diseases caused by some pathogens. Still others help the plants to compete for resources by discouraging competition among different plant species. By studying the diverse chemistries of many different plant species, scientists have discovered many useful compounds that can be used as biopesticides. Plant extracts have long been used to control insects, wherein dating far back children have been deloused using a powder obtained from the dried flowers of the pyrethrum plant (*Tanacetum cinerariifolium*). The first botanical insecticide dates back, when it has been shown that nicotine from tobacco leaves killed plum beetles. Today, there are a number of biopesticide plant extracts being marketed as insecticides and these products fall into several different classes.

Some of the plant products registered as biopesticides include Limonene and Linalool that act on target pests fleas, aphids and mites, also kill fire ants, several types of flies, paper wasps and house crickets. Neem has pesticidal properties against a variety of sucking and chewing insect; while pyrethrum is effective against ants, aphids, roaches, fleas, flies and ticks. Rotenone exhibits insecticidal activity against leaf-feeding insects, such as aphids, certain beetles (asparagus beetle, bean leaf beetle, potato beetle, cucumber beetle, flea beetle, strawberry leaf beetle and others) and caterpillars, as well as fleas and lice on animals. Ryania is found most effective in reducing the larval population of caterpillars such as corn borer, corn earworm, and thrips and others, while Sabadilla has a significant effect against squash bugs, harlequin bugs, thrips, caterpillars, leaf hoppers and stink bug

D. **Enzymes:-** The enzymes are protein molecules, which are the instruments for expression for gene action and that catalyze biochemical reactions. Plant defenses against insect herbivores are mediated, in part, by enzymes that impair digestive processes in the insect gut. Little is known about the evolutionary origins of these enzymes, their distribution in the plant kingdom, or the mechanisms by which they act in the protease-rich environment of the animal digestive tract. The transgenic expression of insecticidal proteins such as α-amylase and protease inhibitors is also being evaluated as a potential protective strategy against insects.

E. **Feeding Deterrents:-** Feeding deterrent is a compound that once ingested by the insect pest, causes it to stop feeding and eventually to starve to death. Crop damage is inhibited and the insect eventually starves to death. The screening for insecticidal principles from several Chinese medicinal herbs showed that the root bark of *Dictamnus dasycarpus* possessed significant feeding deterrence against two stored-product insects (*Tribolium castaneum* and *Sitophilus zeamais*). From the methanol extract, two feeding deterrents have been isolated by bioassay-guided fractionation. The compounds have been identified as *Fraxinellone* and *Dictamnine* from their spectroscopic data. *Fraxinellone* and *Dictamnine* have demonstrated to possess feeding deterrent activity against adults and larvae of T. castaneum as well as S. zeamais.

F. **Repellents:-** An insect repellent (also commonly called bug spray) is a substance applied to skin, clothing, or other surfaces which discourages insects (and arthropods in general) from landing or climbing on that surface. Typically compounds which release odors that are unappealing or irritating to insects, include garlic or pepper based insecticides. Insect repellents help to prevent and control the outbreak of insect-borne diseases such as malaria, dengue fever and bubonic plague. Pest creatures commonly serving as vectors for disease include the insects flea, fly, mosquito and the arachnid tick. Repellents researched, which have been shown to provide significantly better protection are N,N-diethyl-m-toluamide, essential oil of the lemon eucalyptus (*Corymbia citriodora*), Icaridin, Nepetalactone, Dimethyl carbate, Dimethyl phthalate, Citronella oil, Neem oil and Metofluthrin, which are promising group of repellents. Sometimes, the synthetic repellents tend to be more effective and longer lasting than natural repellents.

Repellants, confessants, and irritants are not usually toxic to insects, but interfere with their normal behaviour and thereby keep the insects from causing damage. Mothballs and mosquito repellants are familiar examples. Wide scale use of synthetic sex pheromones may confuse insects sufficiently that they are unable to mate and produce offspring; a few such products are commercially available, such as for codling moth control in apples. Using insect pheromones in this manner is called mating disruption, a practice that works best in large commercial plantings where it is less likely that mated females will move into the planting from outside of the treated area. Many of these types of behavioural chemicals break down or wash away quickly, and must be reapplied frequently, used in an enclosed area, or formulated to release slowly over a long period.

G. **Confusants:-** Confusants are compounds that imitate food sources and are used as traps or decoys to draw damaging insects away from crops. Confusants can also be formulated as concentrated sprays designed to overwhelm insects with so many sources of stimuli that they cannot locate the crop. Not only are plant extracts used directly as insecticides, but they are used also as a source for synthetic insecticides based on analogues developed in the laboratory. Scientists have modified molecules found in plants to be more toxic or more persistent. Common examples of this can be found in the pyrethroid and neonicitinoid families of insecticides, derived from molecules isolated from plants like pyrethrum (*T. cinerariifolium*) and tobacco. The damage caused by the whiteflies *Dialeuropora decempuncta*, *Aleurodicus disperses* Russell, and *Aleuroclava sp*., to mulberry plants is extensive and they cause a huge economic loss to mulberry leaves which affects silkworm rearing. Previous investigations indicate that neem-based insecticides may be a suitable alternative for pest management in sericulture. Use of neem products in sericultural pest control has many merits. It will also help in the successful introduction of biological controls in plants. Several exotic parasitoids have been found to be highly effective, including two aphelinid parasitoids *Encarsia haitiensis* Dozier and *E. meritoria* Gahan. These are most promising and are reported to minimize the fly pest populations. The parasitization potential and behaviour of the parasitoids have to be carefully assessed before they are introduced to control fly pest populations. There is a need for careful assessment of all these advanced biological technologies in order to develop a profitable, safe and durable approach for whitefly control in sericulture.

H. **Plant Growth Regulators:-** Simply, plant growth regulators also known as growth regulators or plant hormones are chemicals used to alter the growth of a plant or plant part. From the regulatory control perspective, plant growth regulators are classified under pesticides. Natural plant regulators are chemicals produced by plants that have toxic, inhibitory, stimulatory, or other modifying effects on the same or other species of plants. Some of these are termed plant hormones or phytohormones. Some plant oils can act as effective contact herbicides through a variety of mechanisms such as disrupting cell membranes in plant tissue, inhibiting amino acid synthesis, or precluding production of enzymes necessary for photosynthesis. Examples of minimum risk pesticides include products containing active ingredients of cottonseed, clove and garlic oils, cedar oil, and rosemary and peppermint oil.

I. **Insect Growth Regulators:-** The insect growth regulators (IGRs) have been used in a variety of practical applications and are described as agents that elicit their primary action on insect metabolism, ultimately interfering and disrupting the process of growth, development and metamorphosis of the target insects, particularly when applied during the sensitive period of insect development. Biochemical insect growth regulators have a unique mode of action separate from most chemical insecticides. Generally speaking, these products prevent insects from reaching a reproductive stage, thereby reducing the expansion of pest populations. The direct impact of IGRs on target pests combined with the preservation of beneficial insects and pollinators aids to growers in maximizing yield and product quality. The IGRs can be divided into two broad categories; i.e., those that disrupt the hormonal regulation of insect metamorphosis, and those that disrupt the synthesis of chitin, a principal component of insect exoskeletons. Agricultural applications currently focus on the first category of compounds, and these products are also known as „hormone mimics". Azadirachtin is one of the most widely used botanical insect growth regulators. Because of its structural resemblance to the natural insect molting hormone ecdysone, azadirachtin interrupts molting, metamorphosis and development of the female reproductive system. Immature insects exposed to azadirachtin (mainly by ingestion) may molt prematurely or die before they can complete a properly timed molt. Those insects that survive a treatment are likely to develop into deformed adults incapable of feeding, dispersing, or reproducing. Since beneficial insects, predators and pollinators do not feed directly on the treated foliage, biochemical insect growth regulators are considered „soft" on beneficial insects such as honeybees, lady bugs, green lacewings and the parasitic wasps. Due to their unique mode of action, biochemical insect growth regulators have played an important role in integrated pest management systems and as an effective resistance management tool. A good example is the use of azadirachtin IGR in aphid population management programs for lettuce crop protection. Integrated use of azadirachtin provides control by impacting the larvae and nymphs of multiple aphid species, breaking the life cycle before they become reproducing adults. Another azadirachtin success story is its use for pear psylla control on pears, where growers integrate traditional control products, azadirachtin and kaolin clay for an effective pest management with significantly reduced use of harmful chemical insecticides.

Biotic agents/Natural enemies Predators

- They consume several to many prey over the course of their development, they are free living and they are usually as big as or bigger than their prey.
- Lady beetles, rove beetles, many ground beetles, lacewings, true bugs such as Podisus and Orius, syrphid fly larvae, mantids, spiders, and mites such as *Phytoseiulus* and *Amblyseius*.
- **Parasitoids:-**
  - ✓ Parasitoids are almost the same size as their hosts, and their development always kills the host insect.
  - ✓ An adult parasitoid deposits one or more eggs into or onto the body of a host insect or somewhere in the host's habitat.
  - ✓ The larva that hatches from each egg feeds internally or externally on the host's tissues and body fluids, consuming it slowly.
  - ✓ Later in development, the host dies and the parasitoid pupates inside or outside of the host's body.
  - ✓ Bathyplectes, trichogramma, encarsia, muscidifurax etc.

5. VERMICOMPOST

Vermicompost is an organic manure (bio-fertilizer) produced as the vermicast by earth worm feeding on biological waste material; plant residues.

Vermicomposting is the process of turning organic debris into worm castings. The worm castings are very important to the fertility of the soil. The castings contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium. Castings contain: 5 times the available nitrogen, 7 times the available potash, and 1 ½ times more calcium than found in good topsoil. Several researchers have demonstrated that earthworm castings have excellent aeration, porosity, structure, drainage, and moisture-holding capacity. The content of the earthworm castings, along with the natural tillage by the worms burrowing action, enhances the permeability of water in the soil. Worm castings can hold close to nine times their weight in water. "Vermiconversion," or using earthworms to convert waste into soil additives, has been done on a relatively small scale for some time. A recommended rate of vermicompost application is 15-20 percent.

Nutritive value of vermicompost

Organic carbon	9.5 – 17.98%
C/N Ratio	11.64
Nitrogen	1.5 – 2.50%
Phosphorous	1.6 – 1.8%
Potassium	1.0-1.5%
Sodium	0.06 – 0.30%
Calcium and Magnesium	22.67 to 47.60 meq/100g
Copper	2 – 9.50 mg kg-1
Iron	2 – 9.30 mg kg-1
Zinc	5.70 – 11.50 mg kg-1
Sulphur	128 – 548 mg kg-1

Advantage of Vermicompost

- Actinomycetes found in Vermicompost 8 time more than FYM, that increase resistant power of crop against pest and diseases.
- Vermicompost is rich in all essential plant nutrients.
- Provides excellent effect on overall plant growth, encourages the growth of newshoots / leaves and improves the quality and shelf life of the produce.
- Vermicompost is free flowing, easy to apply, handle and store and does not have badodour.
- It improves soil structure, texture, aeration, and waterholding capacity and prevents soil erosion.
- Vermicompost is rich in beneficial micro flora such as a fixers, P-solubilizers,cellulose decomposing micro-flora etc in addition to improve soil environment.
- Vermicompost contains earthworm cocoons and increases the population andactivity of earthworm in the soil.
- It neutralizes the soil protection.

- It prevents nutrient losses and increases the use efficiency of chemical fertilizers.
- Vermicompost is free from pathogens, toxic elements, weed seeds etc.
- Vermicompost minimizes the incidence of pest and diseases.
- It enhances the decomposition of organic matter in soil.
- It contains valuable vitamins, enzymes and hormones like auxins, gibberellins etc.

Species of Earthworm:- In nature found about 700 species of earthworm. In which 293 are useful for agriculture. Generally they are classified into three group:-

Epigeic: surface dwellers:- Epigeic earthworms live in areas containing high amounts of organic matter. They live at or near the soil surface and feed on leaf litter, decaying plant roots or dung. These earthworms do not form permanent burrows. Epigeic species tend to have dark skin colour (pigmentation). The pigmentation acts as camouflage as they move through the leaf litter. It also helps to protect them from UV rays. Being close to the ground surface exposes the earthworms to predators so their muscles are strong and thick in proportion to their length, allowing for quick movement. Being so close to the surface also makes them vulnerable to stock treading in intensively grazed paddocks. Epigeic species tend to be small (1–18 cm in length). Introduced epigeic earthworms tend to live in compost (such as the introduced tiger worm *Eisenia fetida*, which cannot survive in soil) and under logs and dung. Native species usually live in forest litter. *Dendrobaena octaedra*, *Dendrobaena attemsi*, *Dendrodrilus rubidus*, *Eiseniella tetraedra*, *Eisenia fetida, Heliodrilus oculatus*, *Lumbricus rubellus*, *Lumbricus castaneus*, *Lumbricus festivus*, *Lumbricus friendi, Satchellius mammalis*

Endogeic: topsoil dwellers:- Endogeic earthworms are the most common earthworm species found in New Zealand. Their niche is the top 20 cm depth of soil. Endogeic earthworms eat large amounts of soil and the organic matter in it, although species sometimes come to the surface to search for food. They form shallow semi-permanent burrows. Endogeic earthworms have some pigmentation. Their muscle layers are not as thick nor do they move as quickly as epigeic earthworms. Endogeic species range in size from 2.5–30 cm. Introduced endogeic earthworms are often found in agricultural soils, while native endogeic earthworms are often found in tussock grasslands. *Allolobophora chlorotica*, *Apporectodea caliginosa*, *Apporectodea icterica*, *Apporectodea rosea*, *Murchieona muldali*, *Octolasion cyaneum* and *Octolasion lacteum.*

Anecic: subsoil dwellers:- Anecic earthworms live in permanent burrows as deep as 3 m below the soil surface. They collect food from the soil surface and ingest organic matter from the soil. Anecic earthworms form extensive burrows that extend laterally and vertically through the subsoil. Their burrows can be up to 2 cm in diameter. Introduced anecic earthworms have some pigmentation. Indigenous anecic species tend to be sluggish and have weakly developed muscles. Because they live so deeply in the soil, native anecic species have little pigmentation, and being so pale, they are often referred to as milk worms. These deep-burrowing species are also the longest, ranging from 3 cm up to a very large 1.4 m. eg:- *Lumbricus terrestris* and *Apporectodea longa.*

Vermicompost by *Eisenia fetida*

- *Eisenia fetida* is most suitable for Rajasthan climate.
- *Eisenia fetida* 3-4 inch in length and half gram in weight.

- Red in colour.
- It is eating 90% organic matter and 10% soil. It is laying 2-3 cocoon in a week.
- Every cocoon has 3-4 egg.
- A adult earthworm laying 250 eggs in six months.

Selection of site and bed preparation
Shad is required for composting.
Bed Size:- 40-50x3-4x3-4 fit
Preparation of Vermicompost

- Vermibed (vermes= earthworms; bed= bedding) is the actual layer of good moist loamy soil placed at the bottom, about 15 to 20 cm thick above a thin layer (5 cm) of broken bricks and coarse sand.
- Earthworms are introduced into the loamy soil, which the worms will inhabit as their home. 150 earthworms may be introduced into a compost pit of about 2m x 1m x 0.75m, with a vermibed of about 15 to 20 cm thick.
- Handful-lumps of fresh cattle dung are then placed at random over the vermibed. The compost pit is then layered to about 5 cm with dry leaves or preferably chopped hay/straw or agricultural waste biomass. For the next 30 days the pit is kept moist by watering it whenever necessary.
- The bed should neither be dry or soggy. The pit may then be covered with coconut or Palmyra leaves or an old jute (gunny) bag to discourage birds.
- Plastic sheets on the bed are to be avoided as they trap heat. After the first 30 days, wet organic waste of animal and/or plant origin from the kitchen or hotel or hostel or farm that has been pre-digested is spread over it to a thickness of about 5 cm. This can be repeated twice a week.
- All these organic wastes can be turned over or mixed periodically with a pickaxe or a spade.
- Regular watering should be done to keep the right amount of moisture in the pits. If the weather is very dry it should be dampened periodically.

Harvesting of Vermicompost

- The compost is ready when the material is moderately loose and crumbly and the colour of the compost is dark brown. It will be black, granular, lightweight and humus-rich.
- In 60 to 90 days (depends up on the size of the pits) the compost should be ready as indicated by the presence of earthworm castings (vermicompost) on the top of the bed. Vermicompost can now be harvested from the bin/pit.
- To facilitate separating the worms from the compost, stop watering two to three days before emptying the beds. This will force about 80 per cent of the worms to the bottom of the bed.
- The worms can also be separated by using sieves/meshes. The earthworms and the thicker material, which remains on top of the sieve, goes back in the bin and the process starts again. The smell of the compost is earth-like. Any bad odour if formed is a sign that fermentation has not reached its final goal and that the bacterial processes are still going on. A musty smell indicates the presence of mold or overheating which leads to loss of nitrogen. If this happens, aerate the heap better or start again, adding more fibrous material and keeping the heap drier. The compost is then sieved before being packed.

- The harvested material should be placed in a heap in the sun so that most of the worms move down to the cool base of the heap.
- In the two or four pit system, watering should be stopped in the first chamber so that worms will automatically move to another chamber where the required environment for the worms are maintained in a cyclic manner and harvesting can be done continuously in cycles.

Precautions for compost making:

- Moisture level in the bed should not exceed 40-50%.Water logging in the bed leads to anaerobic condition and change in pH of medium.This hampers normal activities of worms leading to weight loss and decline in worm biomass and population.
- Temperature of bed should be within the range of 20-30 degree centigrade.
- Worms should not be injured during handling.
- Bed should be protected from predators like red ants, white ants, centipedes and others like rats, cats , poultry birds and even dogs
- The organic wastes should be free from plastics, chemicals, pesticides and metals etc.

6. NURSERY

Nursery is a place where seedling, saplings or any other planting materials are raised, propagated, multiplied and sold out for planting.

Importance of Nursery:

1. The young seedlings require special attention during the first few weeks after germination. It is easier and economical to look after the young and tender seedlings growing in nursery bed in a small area than in a large permanent site.

2. Majority of fruit crops are propagated by vegetative means. The propagules require special skill and aftercare before transferring them in the main field. In a controlled condition in nursery all these can be provided successfully by skilled labour.

3. Cuttings are best rooted and grafts are hardened in the mist house chamber which is an integrated part of a nursery.

4. Direct sowing method is not so successful in several crops when compared with transplanting of seedlings raised in nursery.

5. Plants hardened in the nursery are preferred for causality replacement in orchards.

6. Besides these, raising of seedlings or saplings in nursery provides more time for pre-planting operations/preparations.

7. Seasoning/hardening of seedlings against natural odds is only possible in nursery.

Factors affecting the establishment of a nursery:

1. Location and site- Topography,climate , reputation of locality for business and transport facility

3 Selection of soil

2. Water facility

3. Manures

4. Availability of labour

Components of nursery: A nursery should consist of the following components:

1. Building structures: This includes office, sale counter, packing shed, potting shed, store, implement shed and residential quarter.

2. Progeny tree block: The current choice of kind and variety of fruit crops and collection of true to type mother plants have strong bearing on the success and goodwill of a nursery industry. Progeny tree block should be cover 10% area of total nursery area.

3. Propagation structures: structures like green house, glass house, poly house, hot bed, cold frames, lath house, shade house, mist house are used to create congenial condition for the propagation of plants.

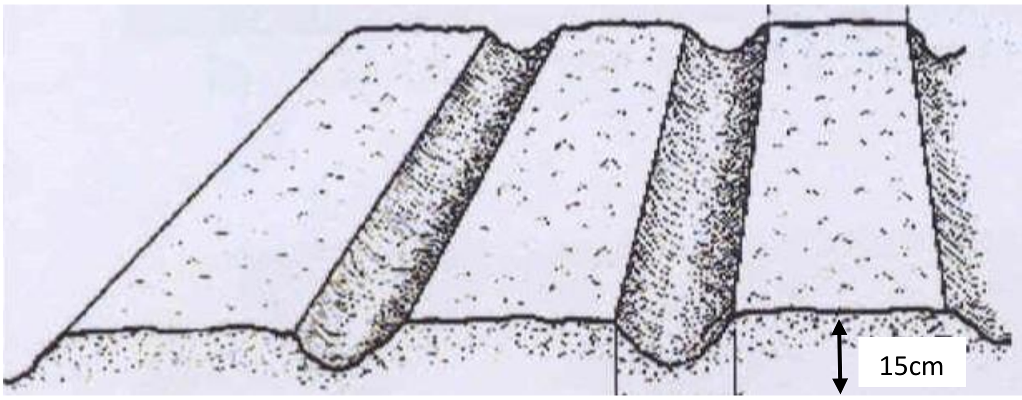
4. Nursery bed:

Types of nursery bed

a) Flat bed b) Raised bed c) Deep bed

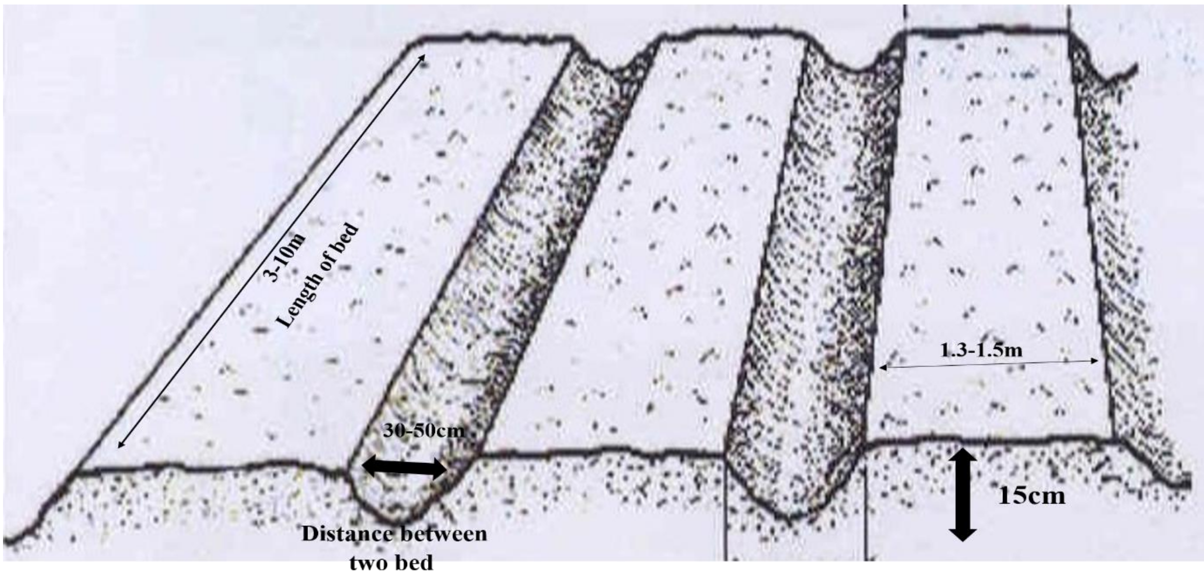
a) Flat Bed: - It is prepared where, there annual rain fall is very less or water drainage system is good.

b) Raised bed:- It is most popular nursery bed. It is prepared where, there annual rainfall is very high or water drainage system is poor. It is generally made 15cm high from ground level.



c) Deep bed:- It is prepare in temperate zone for protection of cold wind. It is generally made 25-30cm deep from ground level.

Size of Bed:-



Soil mixture:-This is the most commonly employed medium for pot plants. It usually consists of red earth, well decomposed cattle manure, leaf mold, river sand and also charcoal in some cases. Soil mixture commonly used for propagation is

- Red earth - 2 parts
- FYM - 1 part

- Sand - 1 part

Fruit Nursery:- Fruit plants seedling are transferred nursery to orchard in 1-2 year old. But papaya seedling should be transplanted in two months old.

- Deciduae fruits seedling should be transplanted in Feb-March month without earth ball.
- Evergreen fruits seedling should be transplanted in June-July month with earth ball.
- Papaya seeds are sowing in Feb-march month and seedling should be transplanting in May.
- **Hardening off:-** Hardening off is the process of moving plants outdoors for a portion of the day to gradually introduce them to the direct sunlight, dry air, and cold nights.
- 15% extra plants should be purchase during purchasing of seedling.
- Seedling plant should be planted in orchard during evening hours.

Vegetable Nursery:-

Vegetable	Area need in nursery for one hector Planting	Seedling age for transplanting
Tomato	100-125m^2	3-4 weeks
Bringle	125-150 m^2	3-4 weeks
Chilli	150-200 m^2	3-4 weeks
Cole Crops	250 m^2	6-8 weeks
Onion	500 m^2	6-8 weeks

Hi-Tech Nurseries:-There is sudden increase in the demand for certain commercial plants. For example Tissue cultured banana, gerbera and carnation etc. It is not possible to fulfill this requirement by ordinary or common nursery practices. There is necessity to have special techniques and methods to meet the demand and only Hi-tech nurseries can satisfy this type of demand. These nurseries grow plants in greenhouse, building of glass or a plastic tunnel, designed to protect young plants from harsh weather, while allowing access to light and ventilation. Modern greenhouses allow automated control of temperature, ventilation, light, watering and feeding. Some also have fold-back roofs to allow "hardening-off" of plants without the need for manual transfer of plants to the outdoor beds.