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 19th 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:

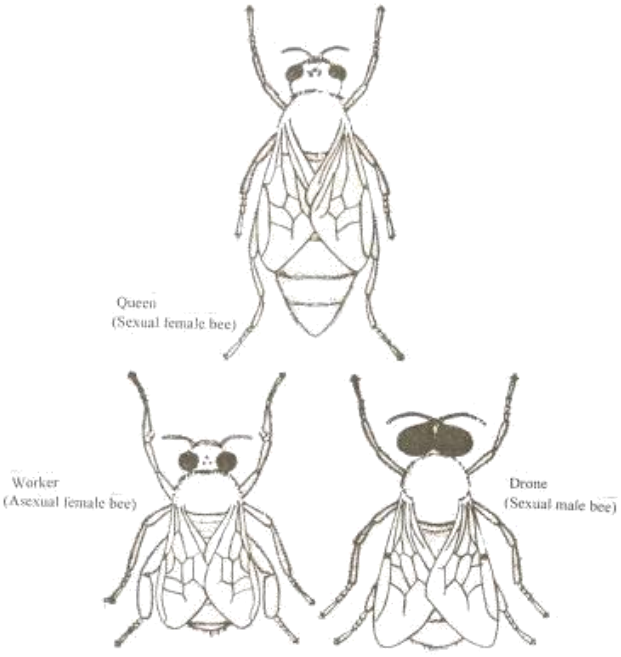
Various castes of honey bee.

(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)

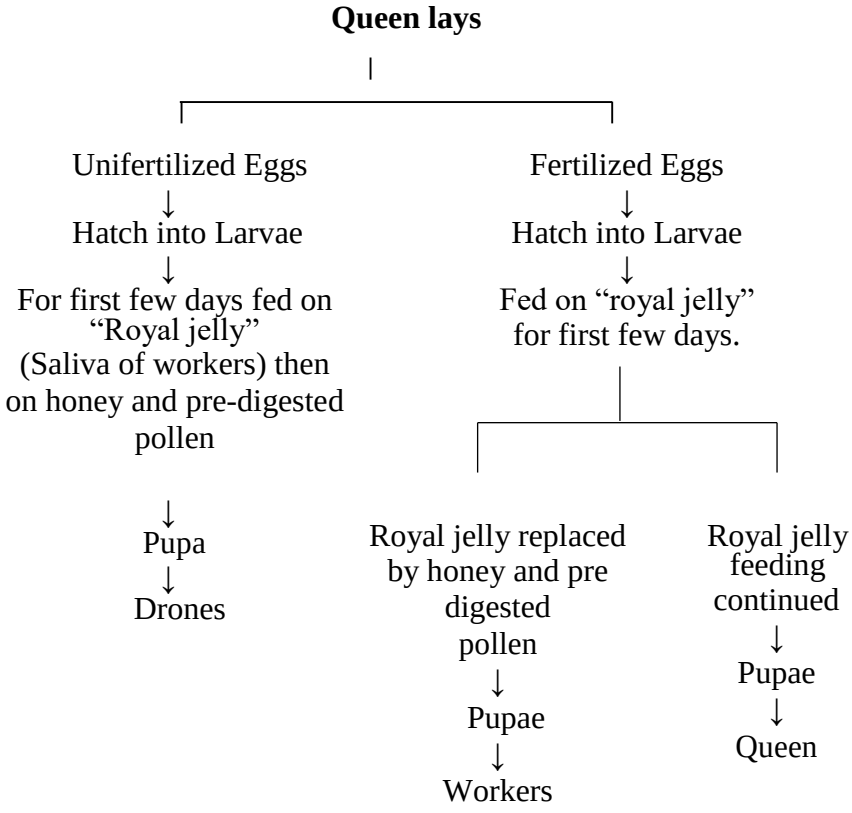
For foraging, some scout bees set out in the morning. On locating good sources of nectar (i.e. flowers) they return to their hive and perform characteristic movements (bee dances) at the comb. These dances communicate to the other worker bees the distance and the direction of the food source. This

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.



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.

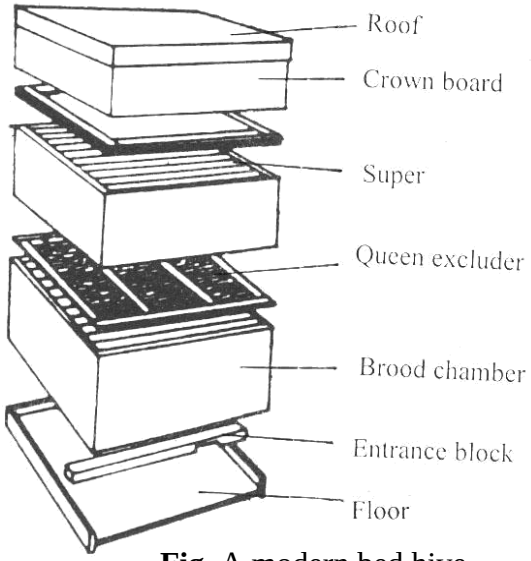


Fig. A modern bed hive.

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.

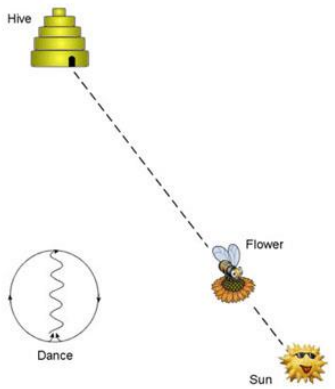
The round dance does not give directional information. Bees elicited into foraging after a round dance fly out of the hive in all directions searching for the food source they know must be there. Odor helps recruited bees find the new flowers in two ways. Bees watching the dance detect fragrance of the 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

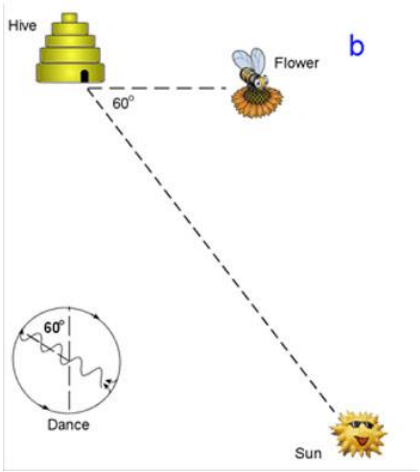
As the food source becomes more distant the round dance is replaced by the waggle dance. There is a gradual transition between the round and waggle dance, taking place through either a figure eight or sickle shaped pattern.

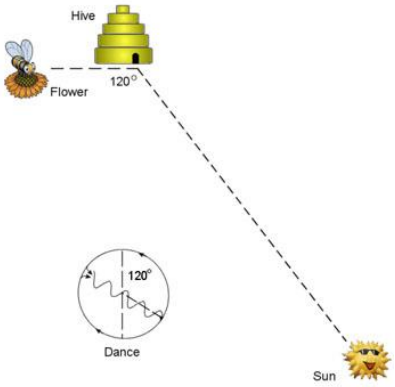
The waggle dance includes information about the direction and energy required to fly to the goal. Energy expenditure (or distance) is indicated by the length of time it takes to make one circuit. For example a bee may dance 8-9 circuits in 15 seconds for a food source 200 meters away, 4-5 for a food 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.

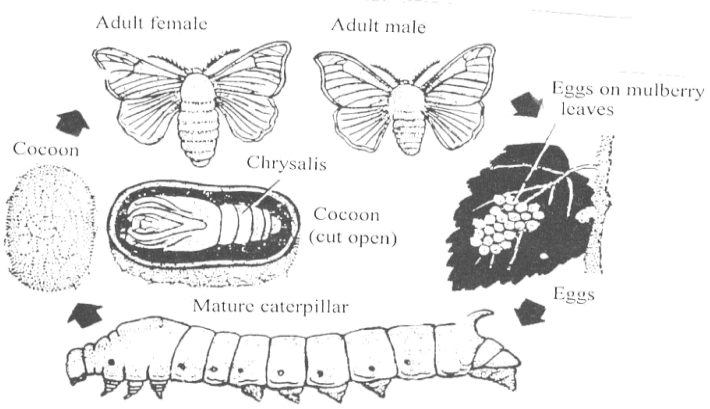
According to the Chinese records, the discovery of silk production from *B. mori* occurred about 2700 BC. It is believed that empress Si-lung-Chi was asked by emperor Huang-ti to find the cause of damaged mulberry leaves on trees in their garden. The empress found white worms eating the leaves. She noticed 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

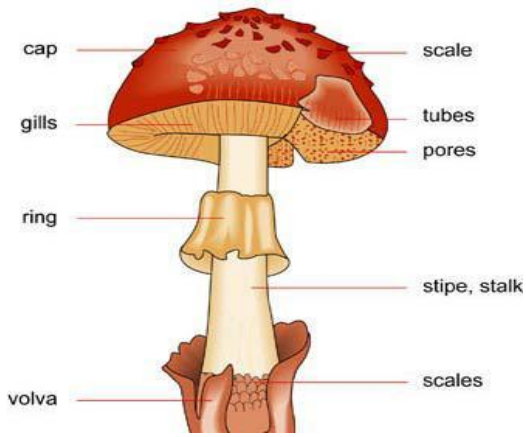
- Bee- keeping helps in three ways – provides honey, provides wax and bring about pollination of agricultural crops.
- There are four common species of honey bee - the wild *Apis dorsata* the two domestic ones *Apis indica* and *Apis mellifera* and the little bee *Apis florea*.
- A bee colony has three 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:

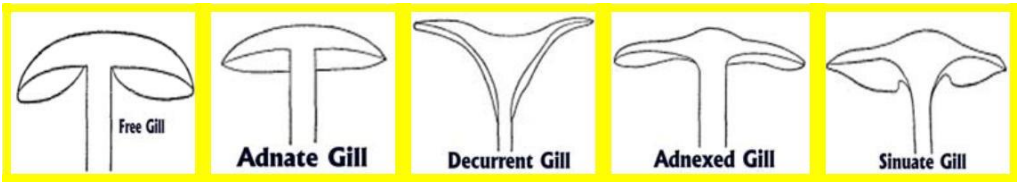
Free gill: when the gills do not touch the stipe or only do so by a fine line.

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*).

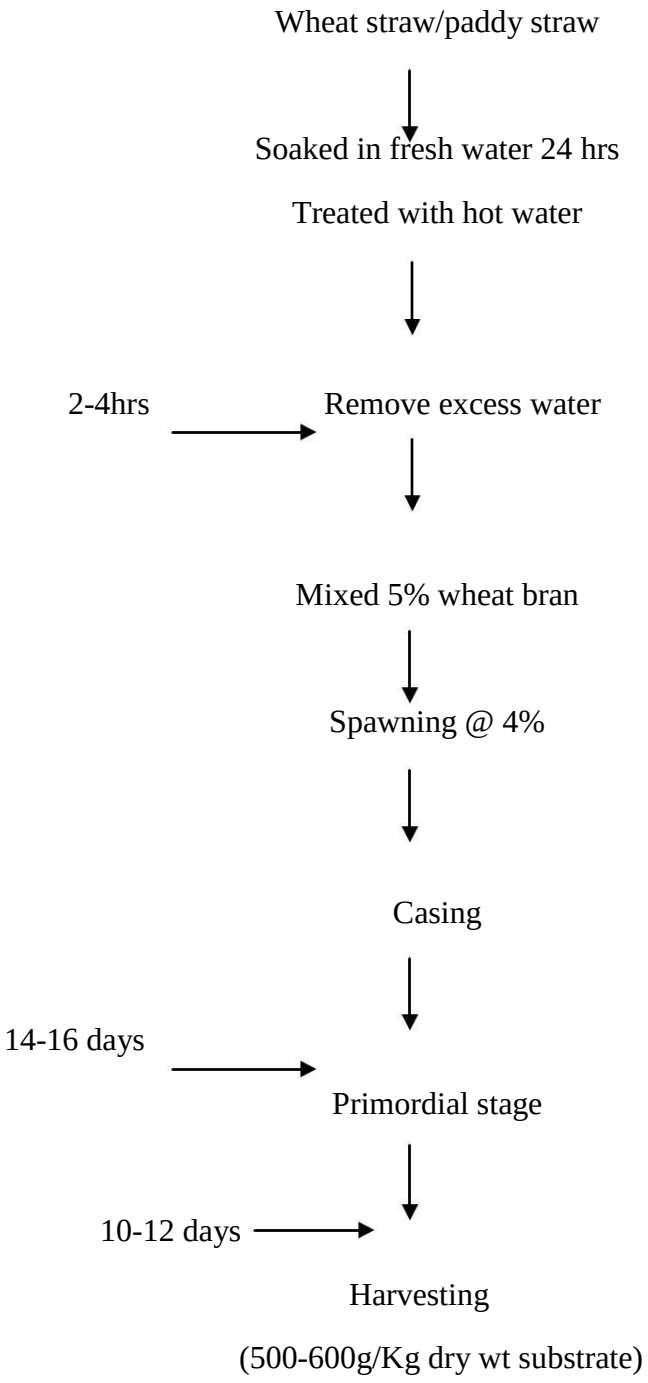
Pleurotus spp. can be grown using various agricultural waste materials. The different species of *Pleurotus* grow within a temperature range of 20^0 to 30^0C. *P. sajor-caju* can tolerate temperature up to 30^0 C although it fruits faster and produces larger mushroom at 25^0 C. *P. fossulatus* is the 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.



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.

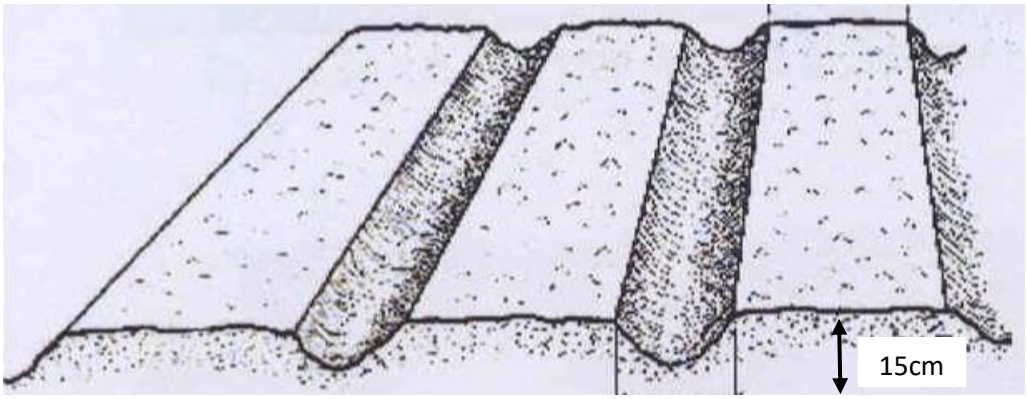
4. Nursery bed:

Types of nursery bed

a) Flat bed b) Raised bed c) Deep bed

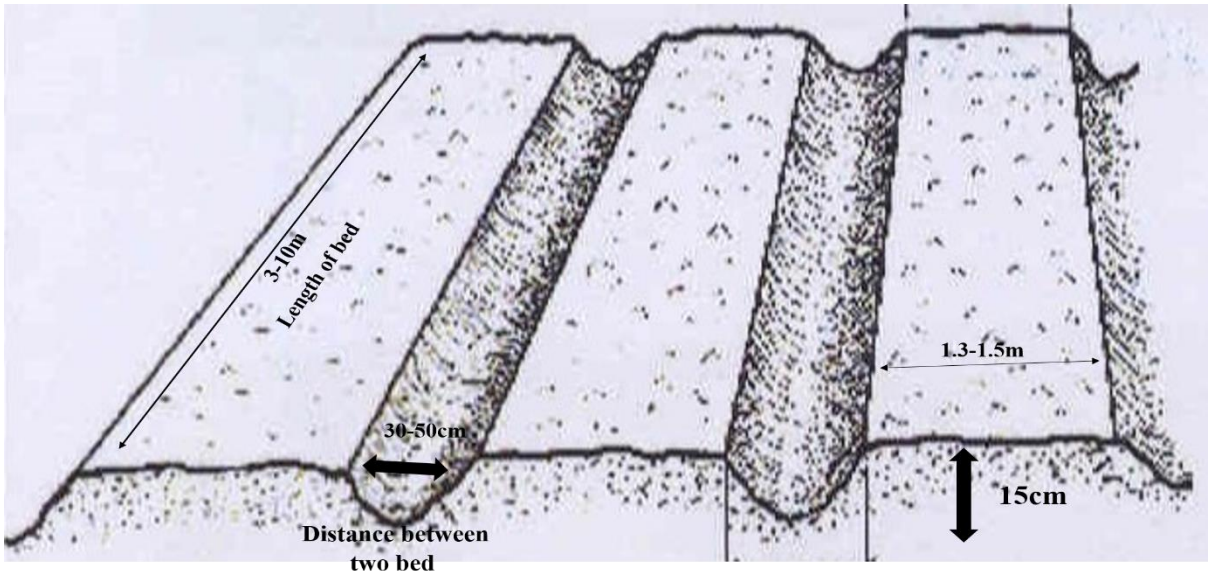
a) Flat Bed: - It is prepared where, there annual rain fall is very less or water drainage system is good.

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.