7. Green House Technology

Can you recall?

1. Green house effect
2. Changing climate scenario
3. Protection from adverse climate
4. Propagating structures

7.1 MEANING, IMPORTANCE AND SCOPE

7.1.1 Meaning : Green houses are protected structures useful for cultivation of certain crops. These structures are erected for protection of crops from adverse climatic conditions and for growing various horticultural crops irrespective of their growing season under controlled conditions. The crops are provided with required CO_2, light, temperature, humidity and air movement which are the most essential components for plant growth. Different types of green houses and polyhouses are used in temperate, tropical and subtropical regions.

The structures made of galvanized material are covered by various types of transparent material which is known as cladding material. Accordingly following different types of greenhouses are used for crop production.

1. **Glass house :** Glass is used as covering material for roof and sides of a frame
2. **Polyhouses :** Polythene sheet is used for covering the frame as cladding material.
3. **Shade house :** A frame is covered with shade nets to protect plants from direct sunlight

The glass houses are used in temperate countries to protect the crops from snow fall and colds. There are several types of green houses and the size of green house also varies according to the requirement. The polythene covered framework is economical. Polythene of 0.10 to 0.15 mm in thickness, which resist to ultraviolet radiation is found most suitable and economical for covering polyhouses. Sometimes, instead of polythene sheet, fiber glass sheets are used for durability but it is more expensive than polythene. In tropical and sub-tropical regions naturally ventilated polyhouses are popular.

7.1.2 Importance of green house technology :

Advantages of greenhouses :

1. The yield may be 10-12 times higher than that of outdoor cultivation depending upon the type of greenhouse, type of crop, environmental control facilities.
2. Reliability of crop increases under greenhouse cultivation.
3. Ideally suited for vegetables and flower crops, especially cut flowers.
4. Year round production of vegetable and floricultural crops.
5. Off-season production of vegetable and fruit crops.
6. Disease-free and genetically superior transplants can be produced continuously.
7. Efficient utilization of chemicals, pesticides to control pest and diseases.
8. Water requirement of crops is very limited with higher efficiency.
9. Maintenance of stock plants, cultivating grafted plant-lets and micro propagated plant-lets.
10. Hardening of tissue cultured plants.
11. Production of quality produce, free of blemishes.
12. Most useful in monitoring and controlling the instability of various ecological system.
13. Modern techniques of Hydroponic (Soil less culture), Aeroponics and Nutrient film techniques are possible only under greenhouse cultivation.
14. Shade net houses are most suitable for nursery.

7.1.3 Scope for green house technology :

As green house technology has lots of advantages, it can be used for profitable commercial cultivation of some crops.

There is a scope for using green house technology for the following reasons

1. Lot of barren land is available which can be deployed for erection of green houses.
2. Low rainfall results in lack of irrigation water. Green house technology could be utilized by storing rain water and using it by drip system (Low evaporative loss of water in green houses).
3. There is a continuous demand for vegetables and flowers throughout the year.
4. There is a scope for propagation and raising nursery.
5. Government schemes are available for promoting green house technology and subsidized rates for plastic and polythene.
6. Large number of unemployed youth could be diverted towards sophisticated farming in green houses.
7. There is a vast scope for export of produce.
8. There is a scope for production of exotic crops as their demand is increasing in the domestic markets.
9. Diverting educated young students towards rural area for using greenhouse technology.
10. Generating employment in erection, maintenance and marketing of greenhouse technology.
11. Ideal technology for marginal farmers.

7.2 TYPE OF GREENHOUSES

Greenhouse structure of various types are used for crop production. Although there are advantages and disadvantages in each type for a particular application, in general there is no single type greenhouse, which can be constituted as the best.

Different types of greenhouses are designed to meet the specific needs. The different types of greenhouses based on shape, utility, material and construction are briefly given below:

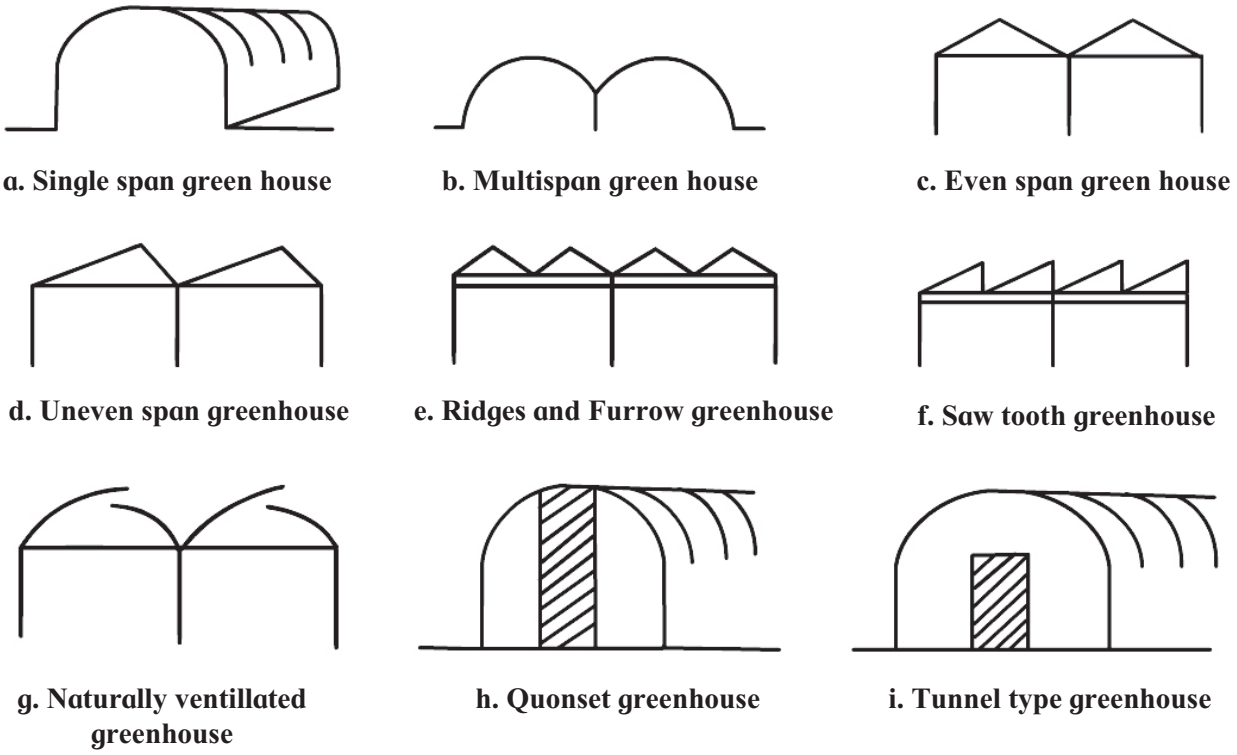


Fig. 7.1 Types of greenhouse based on shape of structures

7.2.1 Greenhouse types based on shape : For the purpose of classification, the uniqueness of cross section of the greenhouses can be considered as a factor. The commonly followed types of greenhouses based on shape are:

a. Single span greenhouse
b. Multi span type
c. Even span type greenhouse
d. Uneven span type greenhouse
e. Ridge and furrow type
f. Saw tooth type
g. Naturally ventilated greenhouse
h. Quonset greenhouse
i. Ground to ground greenhouse or Tunnel type greenhouse

7.2.2 Greenhouse types based on Utility : Classification can be made depending on the functions or utilities. Of the different utilities, artificial cooling and heating are more expensive and elaborate. Hence based on this, they are classified into two types:

a. Greenhouses for active heating
b. Greenhouses for active cooling

7.2.3 Greenhouse types based on construction : The type of construction predominantly is influenced by structural material, though the covering material also influence the type. Based on construction, greenhouses can be classified as :

a. Wooden framed structure
b. Pipe framed structure
c. Truss framed structure

7.2.4 Greenhouse types based on covering material i.e. cladding material : Covering materials are the important component of the greenhouse structure. They have direct influence on greenhouse effect, inside the structure. The type of frames and method of fixing also varies with covering material. Hence based on the type of cladding material they may be classified as

a. Glass house
b. Poly house
c. Shade net house

7.2.5 Greenhouse types based on the cost of construction involved :

a. **High cost Green House :** (Rs. 2000-3000/m^2) – Automatic and fully climate controlled structures
b. **Medium cost Green House :** (Rs. 1000-1200/m^2) – Partially controlled structure
c. **Low cost Green House :** (Rs. 600-800/m^2) – Naturally ventilated polyhouses

The naturally ventilated polyhouses (NVPH) are the most popular in Indian conditions for crop cultivation preferably flowers and vegetables.

Cost Economics of High cost green house: The cost estimates may vary considerably due to crop, cladding material and environmental control system. The additional cost involved per sq. m. is stated below.

Sr. No	Specifications	Cost Rs/m^2
1	When double layer polyethylene used	100
2	CO_2 generation and distribution	150
3	Evaporative cooling	200
4	Heating system	100
5	Humidification system	100
6	Lighting	200
7	Night curtain / Shading system	150
8	Drip system	20
9	Nutrient application system	100
10	Porous flooring	100
11	Benches	150
12	Structural cost	300
	Miscellaneous	180

Average cost of High Cost Greenhouse per square metre is Rs. 2000.00.

7.3 Installation of Green House

7.3.1 Selection of site for green house :

Any type of land could be used for green houses. The site should be away from industrial area to avoid pollution injury to plants. Shade

of building or trees around green house is also harmful. The site should be at a reasonably high level from the ground. Proximity to cities or probable markets is most preferred. Sufficient water supply, labour availability, electricity supply are the other factors of prime importance. There should be a direct approach road.

7.3.2 Design of frame :

G.I. pipes or steel angles are used to make frames. Design and layout of frame varies according to crop, climatic conditions, cost, etc.

The following points should be considered while designing frame.

- Frame should be light in weight.
- Use easily available material (Bamboo or wood could also be used for low cost structure)
- Frame should be even from all sides.
- Slope of roof should be such that water will not fall on crop or stagnate on the roof.
- It should be easy to change the cladding material.
- There should be sufficient ventilation.

The U.V stabilized polyethylene film of 200 micron thickness is mostly used cladding material for polyhouse.

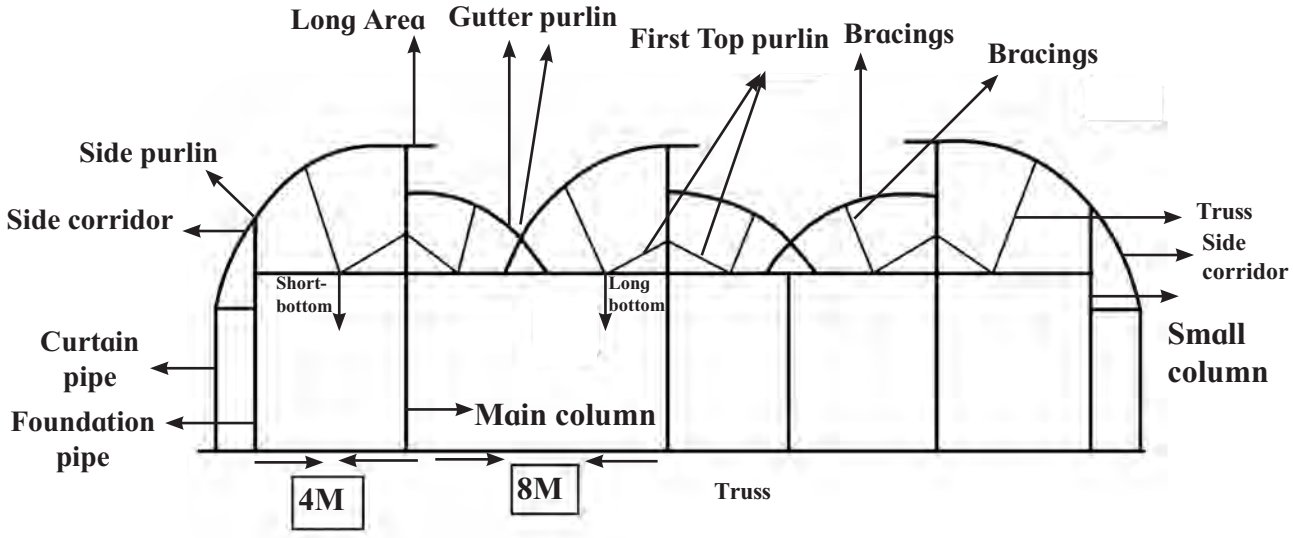


Fig. 7.2 Different parts of greenhouse structure

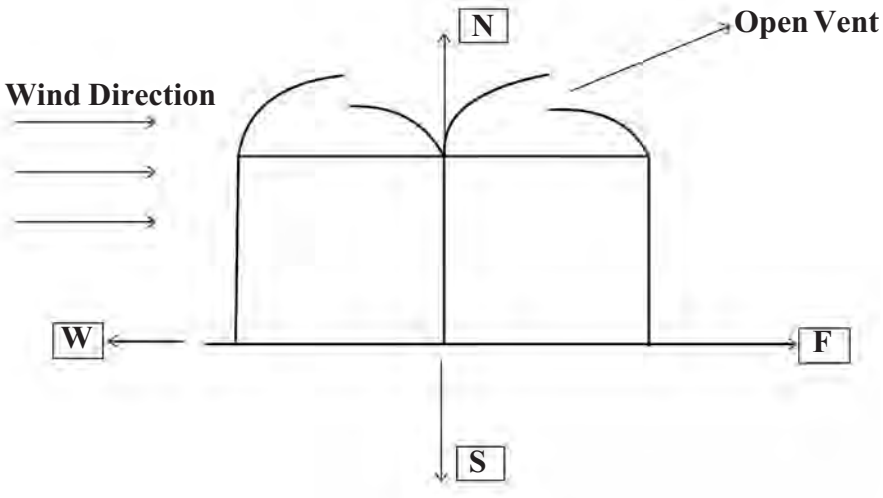


Fig. 7.3 Orientation

7.3.3 Orientation of naturally ventilated green house : The following points should be considered for orientation of NVPH

1. Opening of the top vent should be towards East side.
2. Gutter should be placed in North- South direction.
3. Slope along the gutter should not be more than 2 %.
4. The slope along the gable side should not be more than 1.25 %.

7.3.4 Erection of beds for raising crops :

Cut flowers are generally produced on the ground where as, potted plants are produced on stands. When plants are grown on ground, it is absolutely necessary to sterilize the soil before planting a new crop. Satisfactory sterilization can be achieved by using either chemicals or steam. The process is however cumbersome and time consuming.

Fig. 7.4 Typical naturally ventilated polyhouse (NVPH)

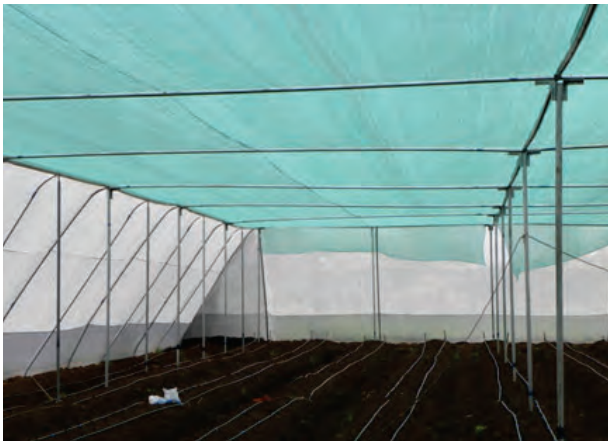


Fig. 7.5 Shadenet house (Flat type for nursery)

So in the recent years greenhouse growers have switched over to soil less growing media, either in polyethylene bags or in troughs. It is always advantageous to grow pot plants on benches. Benches can be either fixed or moveable. With fixed benches we can use sixty per cent of the greenhouse space whereas with moveable benches we can utilize approximately 80 - 85 per cent of the covered area.

7.3.5 Instalation of irrigation system :

Watering in greenhouses can be done through sprinklers and drips. Sprinklers can however be used in the early stages of the crop, before flowering and further to reduce temperature and increase humidity in green house. Drip irrigation can be used in almost all stages of the crop growth. In greenhouse production, it is a usual practice to apply phosphatic and slow release fertilizers as a basal dose to the growing medium. This is supplemented with water soluble fertilizers which are applied along with the irrigation water.

Place one 16mm inline drip lateral at the center of the bed having emitting points at every 30 cm interval with discharge rate of 2 ltr/hr or 4 ltr/hr. Run the drip system to check each emitting point for uniform discharge before covering the beds with polythene mulch.

Can you recall?

Plant requires sunlight, temperature, humidity and CO_2 for its good growth and yield through proper photosynthesis.

7.4 CLIMATE CONTROL IN GREEN HOUSE

The components responsible for plant growth viz. light, temperature, CO_2 , humidity and air circulation can be controlled as under in green house.

7.4.1 Ventilation : It is necessary for proper air circulation in the green houses. For natural circulation keep the sides of green house

(curtains) open during day time only. Exhaust fan may also be used for dragging air out during summer.

7.4.2 Temperature control : Use of fan and pad system, exhausting hot air out, use of screen and using water sprinklers / foggers temperature could be controlled. Shade net of black colour is used at the top below the cladding material to reduce light intensity whenever required.

a. Cooling : Cooling of greenhouse is necessary wherever the outside temperature goes beyond 30º C and also when cool crops are to be grown. Depending upon the cladding material and the ventilation, inside temperature remains 8 to 10º C higher than the outside temperature. In order to create better growing conditions, it will be necessary to cool the greenhouse. This can be done through evaporative cooling method, using horizontal draft fans on one side and cooling pads on the other side. The capacity of the fan and size of the pad depends on the length and width of the greenhouse and also elevation and other parameters. This system is known as fan and pad system which is very effective where the ambient humidity is low, with high temperature.

b. Heating : Heating is required in places where the winter temperature is very low. At higher elevations, where temperatures do not normally go above 30ºC, cooling may not be necessary, only providing proper ventilation will serve the purpose. However, these places may require heating during winter. Greenhouses can be heated with the help of oil burners, hot water (or steam) or propane (or electric) heaters. Heating is a regular process in temperate countries, where temperature goes below 0^0C.

Do you know ?

CO_2 is the main component for photosynthesis which results in good plant growth and yield.

7.4.3 CO_2 control : CO_2 enrichment is done by trapping natural CO_2 in the greenhouse upto 1500-2000 ppm. General level is 300 to 350 ppm whereas at 1200-1500 plant gives good response

a. Enrichment of CO_2 : It can be done by burning mineral oil, paraffin oil or kerosene in gas burners. Produced CO_2 is spread in green house under pressure. If we use 28 litres of gas from such burners on 450 square meter about 1500 ppm CO_2 is generated.

b. Use of liquid CO_2 : Under certain pressure CO_2 is converted in to liquid form which is released in green houses through 3 to 6 mm rubber tubes with minute holes at 10 m distance by regulating valve under low air pressure.

c. Use of solid CO_2 : At low temperature and pressure CO_2 could be converted in to solid form which is known as dry ice. This can be used in green house for enriching carbon- dioxide.

CO_2 enrichment can be done only in fully climate controlled green house. In the naturally ventilated polyhouses side curtains are closed during night which increases CO_2 in Green house. Next morning this stored CO_2 is utilized by plant for photosynthesis then the curtains are opened and excess CO_2 is exhausted.

7.4.4 Control of light intensity : Using UV stabilized sheet and shade net, light intensity is controlled up to 30000 to 60000 lux.

a. Shading : Certain plants are damaged by high light intensities in the greenhouses. Seran cloths with different mesh sizes can be used for providing 25 - 80 per cent shade depending upon the type of crops grown. In the recent years aluminized shade cloth is being used in some of the modern greenhouses. The entire shading system in the greenhouse can be either manually operated or made automatically. Shade nets of various colours are used popularly in NVPH.

Can you recall?

Photoperiodism is the developmental responses of plants to relative lengths of light and dark periods.

b. Photoperiodic control : Several plant species flower only when they are exposed to a specific light duration. On the contrary, these plants species remain vegetative when additional light is given during the dark phase. This phenomenon, which is known as photoperiodism has been effectively utilized in protected cultivation of horticultural crops. Under greenhouse conditions day lengths can be increased by providing artificial light at night or decreased by covering the plants with black polyethylene sheet during day. Most optimum results with artificial lighting can be achieved by night interruption or cyclic lighting with the help of high intensity discharge lights. In contrast, short day condition in greenhouse can be created with fully automatic, semi automatic or manual blackout system using good quality black polyethylene sheets.

For increasing light, incandescent, fluorescent, mercury or sodium vapour lights could be used. Chrysanthemum needs control of photoperiodism for quality flower.

7.4.5 Humidity control : Relative Humidity inside the green house should be 50-80%. It is controlled by using air circulation, using sprinkles and controlling evaporation through opening and closing of side curtains in NVPH.

The environmental conditions to be maintained in greenhouse are :

Climatic Factors	Optimum conditions
Temperature range	During day time - 28^{0}C to 31^{0}C During night time- 15^{0}C to 18^{0}C
Relative humidity	60 to 70%
Light intensity	21500 to 86100 Lux

It can be changed as per crop requirements.

7.5 CULTIVATION OF CROPS IN GREEN HOUSE

Followings different crops are grown in green houses.

Vegetables : Tomato, Capsicum, Lettuce, Broccoli, Celery, Cucumber, Squash, Zukini.

Fruits : Strawberry, Muskmelon

Flower crops : Rose, Gerbera, Carnation, Lilium, Anthurium, Statis, Orchids, crysanthemum etc.

7.5.1 Cultivation of Gerbera : Gerbera is commonly known as Transvaal daisy or Bar berton daisy or African daisy. It is an important commercial cut flower crop. Gerbera flowers have a wide range of colours including yellow, orange, cream-white, pink, brick red, red and various other intermediate colors. In double varieties, bicolor flowers are also available. Gerbera flower stalks are long, thin and have a long vase life. Mini gerbera type bears small sized flowers and standard gerbera are bigger in size which are commercially important.

a. Climate : Bright sunshine accelerates the growth and quality of the flowers, however, in summer this flower needs diffused sunlight. Gerbera plants grown in the locations with insufficient light will not bloom well. The optimum day and night temperature is 27^{0}C and 14^{0}C respectively.

b. Soil : There are two primary factors to be considered while selecting soil for Gerbera cultivation. The soil pH must be between 5.5 to 6.5. The soil salinity level should not exceed 1 ms/cm; For better root growth and better penetration of roots, the soil should be highly porous and well drained. Red lateritic soil is good for Gerbera cultivation as it has all the essential qualities that an ideal soil should have.

c. Preparation of planting bed : In general, Gerbera is grown on raised beds to assist in easier movement and better drainage. The dimensions of the bed should be as follows:

Bed height : 45 cms

Bed width : 70 - 80 cms

Between the beds: 1 feet (30 cm) which is known as path for intercultural operations.

The beds for planting should be highly porous, well drained and airy. Gravel/sand can be added for better drainage. Organic manure is recommended to improve soil texture and

Fig. 7.6 Steps in soil sterilization

to provide nutrition gradually. The soil should be loose all the time and should not be very compact after watering. The upper layer of soil and FYM should be properly mixed. While bed preparation, add Single Super Phosphate (0:16:0) @ 2.5 kg per 100 sq. ft. for better root establishment and Magnesium Sulphate @ 0.5 kg per 100 sq. ft. to take care of deficiency of Mg. Neem cake (@ 1 kg / m^2) is also added for prevention of nematode infestation.

d. Soil sterilization : Soil sterilization is required before plantation of any crop in greenhouse for soil media to manage *Phytophthora* infection and soil borne diseases. There are three main soil sterilization methods available *viz.* steam, solar and chemical out of which chemical method is the most practical method. Formalin is used for soil sterilization @ 7.5/10 lit. of water for 100 sq.m area in the form of spray. The wet crop beds are spread using formalin and covered with black polyethylene mulch sheet. While treating with formalin, care should be taken to wear mask, gloves and apron. Four days after formalin treatment, the polyethylene cover is removed; the beds are raked repeatedly to remove the trapped formalin fumes completely, or washed out by watering prior to transplanting otherwise it may injure the roots of the seedlings. Formalin treatment can be repeated after three crop cycles or whenever necessary.

e. Propagation : Gerbera is commercially propagated by suckers. Side shoots, suckers with some amount of heel are utilized for multiplication.

f. Micro propagation : The plant parts used as explants for micro propagation are shoot tips, leaf mid-rib, capitulum, flower heads, inflorescence and Buds.

g. Varieties : Important varieties of Gerbera are Pre Intenzz, Stanza, Winter Queen, Cacharelle, Jaffa, Sangria, Diana, Thalsa, Sonsara, Paganini, Anneke, Nette, Rosetta, Gloria, Ginna, Ingrid, Pricilla, Alexias, Intense, Sunway, Zingaro, Balance, Rosaline , Dune and Monique. Several new varieties appear every year.

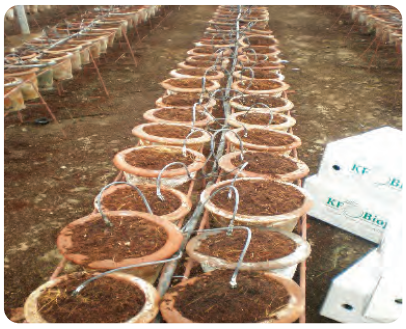
h. Planting : Only tissue cultured plants or seedlings are used for gerbera cultivation under protected conditions. At the time of planting the tissue culture, plant should have at least 4 to 5 leaves. Gerberas are planted on raised bed in two rows.Zigzag plantation system is mostly preferred. While planting, 65% portion of root ball should be kept below ground and rest of the portion i.e. 35% should be kept above the ground for better air circulation in the root

Spreading of laterals for Fertigation on raised beds

Seedling for planting

Planting in soil media

Flowers ready for harvest



Benches with pots for planting in soilless media

Planting in soilless media

Flower harvesting in buckets with adequate amount of water

Box Packing of flowers

Flowers ready for Local market

Fig. 7.7 Cultivation of Gerbera in soil and soilless media

zones. Planting is done either in evening or morning when temperature is low outside.

Ideal planting density and spacing: 8-10 plants/sq.m. or 30 X 30 cm or 40 x 25 cm.

i. Fertilization : Irrigate and fertilize frequently in small quantities for optimum results. Do not fertilize upto three weeks of planting. Always analyze the soil once in 2 - 3 months to decide specific nutrient schedule. Well rotten FYM @ 10-15 kg/100 sq.m. is mixed with soil before sterilization.

Once flowering commences, N:P:K 15:8:35 at the rate of 1.5 g/l water/day is to be given. Micronutrients should be given weekly or fortnightly as per the deficiency symptoms. Boron deficiency causes base of young leaves turn black. Zinc deficiency symptoms can be identified with the C-shaped leaf structure caused by chlorosis on one half of the leaf blade which ceases to expand, while the other half of the leaf is normal.

j. Cultural practices :

i. Weeding and raking of soil : Weeds take the nutrients of the plants and affect the production. Hence, they should be removed from the bed. Due to daily irrigation, the surface of the gerbera bed becomes hard hence raking of soil is done with the help of a raker. It increases soil aeration in the root zone of the plant. This operation should be done regularly, may be once in a week.

ii. Disbudding : Removal of inferior quality flowers at the initial bud stage after plantation is called disbudding. The normal production of gerbera plants starts after 75 - 90 days from the date of plantation. Production of flowers starts 45 days after plantation but initial production is of inferior quality, hence these flowers should be removed from the base of the flowers stalk. this helps in making the plant strong and healthy.

iii. Removal of old leaves : Sanitation helps in keeping the disease and pest infestation below the economic threshold level. The old, dry, infested leaves should be removed from the plant and the production site.

k. Pests and diseases :

i. Diseases : Root rot *(Pythium irregularae, Rhizoctonia solani)* ; Foot rot *(Phytophthora cryptogea)* ; Sclerotium rot *(Sclerotium rolfsii)* ; Blight *(Botrytis cinerea)* ; Powdery mildew *(Erysiphe cichoracearum, Oidium erysiphoides)* ; Leaf spots *(Phyllosticta gerberae, Alternaria spp.)*

ii. Insect-pests : White fly ; Red Spider Mites ; Nematodes ; Aphids ; Leaf miner ; Caterpillars

l. Harvesting : The first harvesting is done after 75 - 90 days after planting. Flowers of most of the varieties are ready to be picked when 2 - 3 whorls of stamens have entirely been developed. The good quality flower has stalk length of 45-55cm, and diameter 4 – 5 cm. Morning or evening is the best time for gerbera flower harvesting. Skilled labours are required for harvesting of gerbera cut flowers. After harvesting the flowers should be kept in a bucket containing clean water. Flowers are very delicate hence they should be carefully handled otherwise can be damaged and their quality gets deteriorated. For harvesting gerbera, no secateurs are required but can be done by just pulling the flower stalk on one side.

m. Yield : 150- 250 flowers/ m^2 / year

Gerbera can be grown in soilless media like coco peat, which is the powdered coco shel commercially available. It requires pots and stands with high initial investment. The uncultivable land, undulated sites can be utilized successfully with this system with higher yields as compared to soil. The commercial life of gerbera is generally 3 years in soil media and 5 - 6 years in soilless media under naturally ventillated polyhouse.

7.5.2 Cultivation of capsicum in green house : Capsicum, also known as sweet pepper, bell pepper or shimla mirch, one of the popular vegetables is grown throughout India. Capsicum is a cool season crop, but it can be grown round the year using protected structures where temperature and relative humidity (RH) can be manipulated. This crop requires day temperature of 25-30^{0}C and night temperature of 18-20^{0}C with relative humidity of 50-60%. If temperature exceeds 35^{0}C or falls below 12^{0}C, fruit setting is affected.

Colored capsicum is in great demand in the urban markets. The demand is mostly driven by hotel and catering industry. The traditionally grown green capsicum, depending on variety and season, usually yields 20-40 tons per hectare in about 4-5 months during winter only. In the greenhouse, the crop duration of green and colored capsicum is about 7 -10 months and yields about 80-100 tonnes per hectare throughout the year.

Cultural and Nursery practices :

a. Selection of varieties :

Growing of capsicum hybrids in green house is useful to obtain continuous and regular flower and fruit setting relatively for a long period of 8 to 10 months. Most of the capsicum hybrids produce green fruits that mature to red, orange or yellow depending on the hybrid. The fruits should have characters such as uniform size and shape preferably four lobes, fruit weight of >150g, uniform coloring after attaining complete maturity, with a better shelf life of more than 5 days under ambient conditions. Selected hybrid should be high yielding, with potential yield of > 40 t/acre. Hybrids should have shorter internodal lengths

Seedling for planting

Planting on raised beds

Supporting the growing plants

Pinching

Vigorous growth after pinching

Coloured fruits

Standing crop

Fig. 7.8 Cultivation of capsicum in greenhouse

(7 to 10 cm), attaining maximum height of 10 feet in a crop period of 10 months. Popularly grown colour wise commercial hybrids in India are:

Green coloured : Indra, Yamuna

Red coloured : Bomby, Triple star, Natasha, Inspiration, Pasarella,

Yellow coloured : Swarna, Orbelle, Bachata.

The capsicum hybrids with high yield potential and uniform size and shape needs to be selected. Generally Red and yellow coloured varieties are selected in the proportion of 60:40 respectively in the same polyhouse. The good quality seedlings of selected varieties with 5 to 6 healthy leaves should be procured from authorised reliable vegetable nursery for planting. Approximately 4000 seedlings are required per acre.

b. Land preparation :

The land should be thoroughly ploughed and soil should be brought to fine tilth. Well decomposed organic manure at the rate of 20-25 kg per sq. mt. is mixed with soil. One application is sufficient to grow three capsicum crops successively. Raised beds are formed after bringing soil to fine tilth. The bed size should be 90-100 cm wide and 15-20 cm height. Between the beds walking space of 45 cm to 50 cm need to be provided for intercultural operations. Soil beds should be sterilized properly, as mentioned earlier.

Do you know ?

Training is done to control direction, shape and size of plant with proper support to have good quality produce.

c. Fertilizer application :

A basal fertilizer dose of 20:25:20 Kg NPK is required per acre and is applied to the beds uniformly before transplanting in the form of 80 kg calcium ammonium nitrate, 125 kg super phosphate and 32 kg muriate of potash or 40 kg sulphate of potash.

d. Application of neem cake and Microbial Bio-control Agents :

Fifteen days before transplanting, neem cake has to be enriched with bioagents like *Trichoderma harzianum* and *Pseudomonas lilacinus*. Neem cake of about 200 Kg is powdered and slightly moistened. *Trichoderma harzianum, Pseudomonas lilacinus* and *Paecilomyces chilmdosporia* each of two kg are mixed thoroughly to the neem cake. The mixture is covered with wet gunny bags or dry grass and left for 8-10 days. Avoid direct exposure to sunlight and rainfall. After 10 days, this enriched mixture of neem cake and bio-agent along with 600 kg of neem cake has to be applied uniformly to the beds for an area of one acre. This is highly useful to reduce the problem of soil borne pathogens and nematodes. It gives quality yield.

e. Laying of drip line :

Place one 16 mm inline drip lateral at the center of the bed with emitting points at every 30 cm interval with discharge rate of 2 ltr/hr. or 4 ltr/hr. Run the drip system to check each emitting point for uniform discharge before covering the beds with polythene mulch.

f. Mulching and Spacing :

Black polyethylene non-recycled mulch film of 30-100 micron thick, 1.2 m wide, is used to cover the planting beds. Holes of 5 cm diameter are made on the polyethylene film as per the recommended spacing (45cm x 30cm). The planting beds are covered with the film by securing the edges of the sheet firmly in the soil. Mulching practice conserves water, controls weeds, and reduces infestation of pests and diseases and results in higher yield and good quality produce.

g. Transplanting :

The planting beds are watered to field capacity before transplanting. Seedlings of 30-35 days old are used for transplanting without any damage to the roots, while taking out the seedlings from individual cells of pro-Trays. Seedlings are transplanted into holes made in polyethylene mulch film at a depth of 5 cm. After transplanting, seedlings are drenched with 3 g/L copper oxychloride or 3 g/L captan or 2 g/L copper hydroxide solution at the base of seedlings @ 25-30 ml per plant. Watering the mulched beds daily during afternoon by using hose pipe for a week continuously is essential to avoid mortality due to heat trapped by mulch sheet.

h. Pruning :

Capsicum plants are pruned to retain four stems. The tip of the plant is pinched after 30 days of transplanting which then splits into two at 5^{th} or 6^{th} node and are left to grow. These two branches again split into two giving rise to four branches. At every node the tip splits into two giving rise to one strong branch and one weak branch. Pruning results in bigger fruits with better quality and high productivity. The capsicum plants can also be pruned to two stems and same level of yield can be maintained.

i. Training :

The main stem of plant is tied with four plastic twine to train along and tied to GI wire grid provided on the top of the plants. This is practiced after four weeks of transplanting. The new branches and plants are trained along the plastic twines.

j. Drip irrigation and Fertilization :

Drip irrigation is given to provide 2-4 litres of water per square meter per day depending on the season. Water soluble fertilizers are given through fertilization for entire crop growth period, starting from third week after transplanting . Fertilization is to be given twice a week as recommended in the table below.

Sr. No	Required fertilizer	Fertilizer dose per fertilisation (kg/ acre)
1.	19:19:19	4 kg
2.	Potassium Nitrate	1.5 kg
3.	Calcium Nitrate	1.5 kg

Capsicum crop is sprayed with water soluble fertilizers like potassium nitrate and calcium nitrate at every 3 week interval after 2 months of transplanting @ 3g/ l as foliar application.

k. Pests and Diseases :

Capsicum being relatively long duration (9-10 months) crop in a polyhouse, the plant parts (vegetative, floral and fruit) are more exposed to adverse conditions which affects the yield, quality and market value of the produce. Hence their identification and management at right stage of the crop should be given importance. The major pests and diseases are:

I. Insect Pest :

i. Thrips
ii. Mites
iii. Aphids
iv. Fruit borer
v. Nematodes
vi . Leaf miner

II. Diseases :

i. Damping off
ii. Powdery mildew
iii. Cercospora leaf spot
iv. Phythopthera

l. Harvesting and yield :

Early morning hours are the best suited for capsicum harvest. Green capsicum can be harvested at 55 to 60 days after transplanting, yellow capsicum at 70-75 days whereas red capsicum at 80-90 days after trnasplanting. Fruits can be harvested once in 3 to 4 days. Yellow and red fruits can be harvested when they have gained 50-80 per cent of the colour development. After harvest fruits should be kept in cool place and avoid direct exposure to sunlight. The capsicum fruits are shrink wrapped with decomposable thin plastic and placed for marketing or packed in boxes. The average yield of capsicum per acre is 30-40 tons.

7.6 PEST AND DISEASE MANAGEMENT IN GREENHOUSE CROPS

7.6.1 Chemical control measures for major pests and diseases :

Sl. No.	Name of pest	Control measures per lit. of water	
1	Spider mites	Abamection or wettable sulphur	0.4 ml
2.	Caterpillars	Methomyl or cypermethrin	1.5 gm 0.5 ml
3.	White fly	Acephate	1.0 gm
4.	Thrips	Acephate or Imidacloprid	1.0 gm 0.4 gm
5.	Aphids	Acephate or Decis	1.0 gm 0.5 ml
6.	Powdery Mildew	Pencozole or Copper oxy-chlorides	0.25 ml 1.5 gm
7.	Nematode	Phorate	6 gm/ sq.m
8.	Leaf miner	Acephate or Abamectin	1.0 gm 0.5 ml
9.	Damping off	Copper Oxy-chloride	1.0 gm

7.6.2 Integrated pest management for greenhouse crops :

Integrated Pest Management is the system that utilizes all suitable techniques in a compatible manner to reduce pest population and maintain them at levels below those causing economic and health injury.

The following steps should be considered to control pest and disease in greenhouse.

1. Use resistant varieties
2. Use pest and disease free healthy planting material.
3. Practice good sanitation techniques.
4. Monitor crop on daily basis
5. Monitor and suppress insect population.
6. Modify the environment
7. Avoid plant stress
8. Use pheromen trap, light trap, sticky cards, etc.

Exercise

Q. 1 Answer the following questions.

A. Select the appropriate alternative and complete the following statements.

1. A frame covered with shade nets to protect plants from direct sunlight is known as …….
   a. Polyhouse b. Shade house
   c. Glass house d. Pack house
2. In the tropical and sub-tropical region ……type of greenhouse is popular.
   a. Naturally ventilated polyhouses
   b. Glass house
   c. Shade net house
   d. Tunnel type
3. Cooling of greenhouse is necessary whenever outside temperature goes beyond ……
   a. 40^0C b. 30^0C
   c. 10^0C d. 20^0C
4. ……. is known as African Daisy.
   a. Carnation b. Gerbera
   c. Capsicum d. Merigold
5. Shrink Wrapping technology is most suitable for packing of ……
   a. Gerbera b. Carnation
   c. Capsicum d. All crops

B. Make the pairs.

A	B
1. Glass house	a. 200 micron
2. UV stabilized polyfilm	b. Capsicum
3. Prunning	c. Glass
	d. Gerbera
	e. 150 micron

C. Find the Odd one out.

1. Soil, Sand, Coco peat, Urea
2. Single Span, Even span, Saw tooth type, Tunnel
3. Temperature, Humidity, Light, CO_2, Irrigation
4. Thrips, Mites, Phytopthera, White fly

D. State true or false.

1. The shade net houses are popular in temperate countries.
2. The temperature under polyhouses is always higher than outside temperature.
3. The covering of the any greenhouse structure is known as cladding material.
4. Seed propagated gerbera is commercially grown outside the green house successfully.

Q.2 Answer in brief.

1. List out any four varieties of gerbera.
2. Explain the use of ventilation for climate control in green house.
3. List out the types of greenhouse on the basis of cost of construction.
4. State how pruning is done in capsicum.
5. Write about harvesting and packing in gerbera.

Q.3 Answer the following questions.

1. Write about installation of irrigation system in greeen house.
2. What are the different types of Greenhouses based on shape?
3. State temperature management in Green house
4. Outline the schedule of fertigation for capsicum cultivation under green house
5. Describe pest disease management for gerbera in greenhouse.

Q. 4. Answer the following questions.

1. Expain different types of greenhouses based on construction.
2. Describe soil sterilization for gerbera cultivation in green house.
3. Describe harvesting and post-harvest management of colored capsicum.

4. Explain the orientation of naturally ventilated poly house.
5. Describe fertilizer application in Capsicum.

Q. 5 Answer the following questions in detail.

1. Describe the cultivation of coloured capsicum under polyhouse condition on following points :
   a. Land preparation
   b. Pruning
   c. Training
2. Explain site selection for Green house.

Q. 6 Answer the following questions in detail.

1. Write the advantages of green house.
2. What is the scope of greenhouse technology under Indian conditions?

Activity

Arrange a visit to a nearby Green house or poly house and study in detail structure, cladding material and different crops grown under green house.

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