NEED AND NECESSITY OF GREENHOUSE EFFECT-A REVIEW

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ABSTRACT

The greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. The greenhouse effect of the atmosphere is named by analogy to greenhouses which get warmer in sunlight. The explanation given in most sources for the warmer temperature in an actual greenhouse is that incident solar radiation in the visible, long-wavelength ultraviolet, and short-wavelength infrared range of the spectrum passes through the glass roof and walls and is absorbed by the floor, earth, and contents, which become warmer and re-emit the energy as longer-wavelength infrared radiation. Glass and other materials used for greenhouse walls do not transmit infrared radiation, so the infrared cannot escape via radioactive transfer. As the structure is not open to the atmosphere, heat also cannot escape via convection, so the temperature inside the greenhouse rises. The greenhouse effect, due to infrared-opaque "greenhouse gases" including carbon dioxide and methane instead of glass, also affects Earth as a whole; there is no convective cooling because no significant amount of air escapes from Earth. Earth's natural greenhouse effect is critical to supporting life. Human activities, primarily the burning of fossil fuels and clearing of forests, have intensified the natural greenhouse effect, causing global warming.

KEYWORDS: Greenhouse, Radiations, Global warming, Environmental parameters, Human activities.

1. INTRODUCTION

A phenomenon in which the atmosphere of a planet traps radiation emitted by its sun, caused by gases such as carbon dioxide, water vapor, and methane that allow incoming sunlight to pass through but retain heat radiated back from the planet's surface. A greenhouse (also called a glasshouse, or, if with sufficient heating, a hothouse) is a structure with walls and roof made chiefly of transparent material, such as glass, in which plants requiring regulated climatic conditions are grown. These structures range in size from small sheds to industrial-sized buildings. A miniature greenhouse is known as a cold frame. The interior of a greenhouse exposed to sunlight becomes significantly warmer than the external ambient temperature, protecting its contents in cold weather. Many commercial glass greenhouses or hothouses are high tech production facilities for vegetables or flowers. The glass greenhouses are filled with equipment including screening installations, heating, cooling, lighting, and may be controlled by a computer to optimize conditions for plant growth. Greenhouses allow for greater control over the growing environment of plants. Depending upon the technical specification of a greenhouse, key factors which may be controlled include temperature, levels of light and shade, irrigation, fertilizer application, and atmospheric humidity. Greenhouses may be used to overcome shortcomings in the growing qualities of a piece of land, such as a short growing season or poor light levels, and they can thereby improve food production in marginal environments.

1.1 Designs and classification of greenhouse

Greenhouses are frames of inflated structure covered with a transparent material in which crops are grown under controlled environment conditions. Greenhouse cultivation as well as other modes of controlled environment cultivation has been evolved to create favorable micro-climates, which favors the crop production could be possible all through the year or part of the year as required. Greenhouses and other technologies for controlled environment plant production are associated with the off-season production of ornamentals and foods of high value in cold climate areas where outdoor production is not possible. The primary environmental parameter traditionally controlled is temperature, usually providing heat to overcome extreme cold conditions. However, environmental control can also include cooling to mitigate excessive temperatures, light control either shading or adding supplemental light, carbon dioxide levels, relative humidity, water, plant nutrients and pest control.
1.2 Classification of greenhouse based on suitability and cost[2-4]

(a) Low cost or low tech greenhouse
Low cost greenhouse is a simple structure constructed with locally available materials such as bamboo, timber etc. The ultra violet (UV) film is used as cladding materials. Unlike conventional or hi-tech greenhouses, no specific control device for regulating environmental parameters inside the greenhouse is provided. Simple techniques are, however, adopted for increasing or decreasing the temperature and humidity. Even light intensity can be reduced by incorporating shading materials like nets. The temperature can be reduced during summer by opening the side walls. Such structure is used as rain shelter for crop cultivation. Otherwise, inside temperature is increased when all sidewalls are covered with plastic film. This type of greenhouse is mainly suitable for cold climatic zone.

(b) Medium-tech greenhouse
Greenhouse users prefers to have manually or semiautomatic control arrangement owing to minimum investment. This type of greenhouse is constructed using galvanized iron (G.I) pipes. The canopy cover is attached with structure with the help of screws. Whole structure is firmly fixed with the ground to withstand the disturbance against wind. Exhaust fans with thermostat are provided to control the temperature. Evaporative cooling pads and misting arrangements are also made to maintain a favorable humidity inside the greenhouse. As these system are semi-automatic, hence, require a lot of attention and care, and it is very difficult and cumbersome to maintain uniform environment throughout the cropping period. These greenhouses are suitable for dry and composite climatic zones.

(c) Hi-tech greenhouse
To overcome some of the difficulties, in medium-tech greenhouse a hi-tech greenhouse, where the entire device, controlling the environment parameters, are supported to function automatically.

1.3 Cost involved
1. Less expensive greenhouse without fan and pad Rs.300 to 500/m²
2. Medium cost greenhouse with pad and fan system Rs.800 to Rs.1100/m² without automation.
3. Expensive greenhouses with fully automatic Rs.2000 to Rs.3500/m² control system.

1.4 Other classifications[3,4]
The greenhouse can also be classified based on type of structures, type of glazing, number of spans, environmental control etc. The various types are as follows.

1.4.1 Based on type of structure
a. Quonset type b. Curved roof type c. Gable roof type.

1.4.2 Based on glazing
a. Glass glazing b. Fiberglass reinforced plastic glazing i. Plain sheet ii. Corrugated sheet

1.4.3 Based on number of spans
a. Free standing or single span b. Multispan or ridge and furrow or gutter connected.

1.4.4 Based on environmental control

1.5 Poly house
The crops grown in open field are exposed to vivid environmental conditions, attack of insects and pests, whereas the polyhouse provides a more stable environment. Polyhouse can be divided in to two types.

(a) Naturally ventilated polyhouse
These polyhouse do not have any environmental control system except for the provision of adequate ventilation and fogger system to prevent basically the damage from weather aberrations and other natural agents.

(b) Environmental controlled polyhouse
This type of polyhouse helps to extend the growing season or permits off-season production by way of controlling light, temperature, humidity, carbon-dioxide level and nature of root medium.

Figure 1: Carnation under high-tech greenhouse.
2. **Orientation of greenhouse/polyhouse**

The design of greenhouse should be based upon sound scientific principles which facilitate controlled environment for the plant growth. Controlled environment plant production systems are used widely throughout the world to produce plant materials and products at a time or place, or of a quality that cannot be obtained outdoors. Controlled environment agriculture requires far more capital investment per unit area than field agriculture and thus must essentially be correspondingly more intensive to justify investment costs. The greenhouse is a structure covered with a transparent material for admitting natural light for plant growth. The main components of greenhouse like structure, covering/glazing and temperature control systems need proper design for healthy growth of plants. The structure has to carry the following loads and is to be designed accordingly.[1-5]

a) **Dead load**: weight of all permanent construction, cladding, heating and cooling equipment, water pipes and all fixed service equipments to the frame.

b) **Live load**: weights superimposed by use (include hanging baskets, shelves and persons working on roof). The greenhouse has to be designed for a maximum of 15 kg per square meter live load. Each member of roof should be capable of supporting 45 kg of concentrated load when applied at its centre.

c) **Wind load**: The structure should be able to withstand winds of 110 kilometer per hour and at least 50 kg per square meter of wind pressure.

d) **Snow load**: These are to be taken as per the average snowfall of the location.

The greenhouse should be able to take dead load plus live load or dead load plus wind load plus half the live load.

The greenhouses are to be fabricated out of Galvanized Iron Pipes. The foundation can be 60cmx60cmx60cm or 30 cm diameter and one meter depth in PCC of 1:4:8 ratio. The vertical poles should also be covered to the height of 60 cm by PCC with a thickness of 5cm. This avoids the rusting of the poles.

Orientation of the greenhouse is a compromise for wind direction, latitude of location and type of temperature control. Single greenhouses with latitude above 40°N should have ridge running east to west to allow low angle light to enter from side rather than ends. Below 40°N the ridge of single greenhouses should be oriented from north to south, since the angle of sun is much higher. This orientation permits the movement of shadow of the gutter across the green house. The location and orientation of the greenhouse should avoid falling of shadow on the adjacent greenhouses. To avoid the shading effect from one green house to another greenhouse these should be oriented East to West. However, the wind direction and latitude are also to be considered.[5]

2.1 **Wind effects**

If the greenhouse is naturally ventilated, the advantage of natural wind direction has to be taken to the maximum possible. The maximum dimension (length) of greenhouse should be perpendicular to the wind direction especially in summer. For fan and pad greenhouse the natural wind direction should be same as the air blown by fan.

2.1.1 **Size of the greenhouse**

The dimension of NAV GH should not be more than 50m x 50m. Bigger the greenhouse, more will be the temperature build up due to poor ventilation. The length of evaporatively cooled greenhouse should not be more than 60m.

2.1.2 **Spacing between greenhouses**

The spacing between naturally ventilated green house should be 10 to 15 m so that the exhaust from one greenhouse should not enter the adjacent greenhouse.

2.1.3 **Height of greenhouse**

The maximum height can be up to 5m for 50m x 50m greenhouse and this can be reduced as per the reduced size of the green house. Higher is the greenhouse more is the wind load for structure and glazing. The side ventilation can be of 2 m width and roof ventilation is 1m in width.

2.1.4 **Structural design**[6]

The greenhouses are to be designed for necessary safety, serviceability, general structural integrity and suitability. The structure should be able to take all the necessary dead, live, wind and snow loads. The foundation, columns and trusses are to be designed accordingly. The greenhouse structures are to be designed to take up the loads as per design loads prescribed by the National Greenhouse Manufactures Association (NGMA of USA) standards –1994.

4. **Components of greenhouse**[3,5]

- **Roof**: transparent cover of a green house.
- **Gable**: transparent wall of a green house.
- **Cladding material**: transparent material mounted on the walls and roof of a green house.
- **Rigid cladding material**: cladding material with such a degree of rigidity that any deformation of the structure may result in damage to it. Ex. Glass.
- **Flexible cladding material**: cladding material with such a degree of flexibility that any deformation of the structure will not result in damage to it. Ex. Plastic film.
- **Gutter**: collects and drains rain water and snow which is place at an elevated level between two spans.
- **Column**: vertical structure member carrying the green house structure.
- **Purlin**: a member who connects cladding supporting bars to the columns.
- **Ridge**: highest horizontal section in top of the roof.
- **Girder**: horizontal structure member, connecting columns on gutter height.
Bracings: To support the structure against wind.
Arches: Member supporting covering materials.
Foundation pipe: Connection between the structure and ground.
Span width: Center to center distance of the gutters in multispan houses.
Green house length: Dimension of the green house in the direction of gable.
Green house width: Dimension of the green house in the direction of the gutter.

4.1 Cladding material
Polythene proves to be an economical cladding material. Now long lasting, unbreakable and light roofing panels-UV stabilized clear fiber glass and polycarbonate panels are available. Plastics are used in tropical and subtropical areas compared to glass/fiberglass owing to their economical feasibility. Plastics create enclosed ecosystems for plant growth. LDPE (low density polyethylene)/LLDPE (linear low density polyethylene) will last for 3-4 years compared to polythene without UV stabilizers.

4.2 Comparison of different kinds of covering materials
Selection of suitable containers depends upon the crop to be produced in greenhouse, plant characteristics like crop stage, duration, vigour, growth habit, root system, etc. Generally long duration, deep rooted and vigorous crop plants require bigger containers compared to short duration, shallow and less vigorous ones. The containers provide optimum condition for germination of seed and growth and development of transplants (Table 1).[2,5]

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Type</th>
<th>Durability</th>
<th>Transmission Light</th>
<th>Transmission Heat</th>
<th>Maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Polyethylene</td>
<td>One year</td>
<td>90%</td>
<td>70%</td>
<td>Very high</td>
</tr>
<tr>
<td>2.</td>
<td>Polyethylene UV resistant</td>
<td>Two years</td>
<td>90%</td>
<td>70%</td>
<td>High</td>
</tr>
<tr>
<td>3.</td>
<td>Fiber Glass</td>
<td>Seven years</td>
<td>90%</td>
<td>5%</td>
<td>Low</td>
</tr>
<tr>
<td>4.</td>
<td>Tedlar coated Fiber Glass</td>
<td>Fifteen years</td>
<td>90%</td>
<td>5%</td>
<td>Low</td>
</tr>
<tr>
<td>5.</td>
<td>Double strength Glass</td>
<td>Fifty years</td>
<td>90%</td>
<td>5%</td>
<td>Low</td>
</tr>
<tr>
<td>6.</td>
<td>Poly carbonate</td>
<td>Fifty years</td>
<td>90%</td>
<td>5%</td>
<td>Very low</td>
</tr>
</tbody>
</table>

5. Environmental factors influencing greenhouse cultivation
Plants need an optimum temperature for maximum yield and quality. The greenhouses in plain and coastal region of India need cooling. The greenhouses in mild climates and coastal region can be naturally ventilated. The greenhouses for hot summer climates of northern plains have to be evaporative cooled or with fan and pad (FP). The greenhouses for northern plains may require both cooling and heating depending on the crop.

5.1 Natural ventilation
The greenhouse has to be thoroughly ventilated for control of temperature. It should be noticed that the temperature built up in the greenhouse is not exceeding 2°C throughout the year. Further during hot months the temperature in the greenhouse was same as the ambient temperature.

5.2 Unconventional method of heating and cooling
a) Hot and cold water can be sprinkled on the greenhouse covered externally with the shade net.
b) Use of earth tunnel for cooling in summer and heating in winter.
c) Construction of greenhouse in a trench for heating in winter cooling in summer.
d) Circulating the bore well water in pipes laid on the floor of the greenhouse.

5.2.1 Heating of greenhouse
The heating of greenhouses in cold climates like winter in North India or Himalayan Region at high altitudes is advisable for getting better produce. Double covering of glazing with an air cushion of 2 cm to 10 cm reduces the heating load considerably.

5.2.2 Heating system
It can be of the following types: a. Boiler 1. with hot water tube 2. with steam pipes b. Unit heaters c. Infrared heaters d. Solar heaters.

a. Boiler
This system is used for very big greenhouses and is a centralized system of heating. The boiler of necessary capacity is provided in the greenhouse. The fuel for boiler can be coal or fuel oil. The heating of the greenhouse is generally done through hot water at 85°C or steam at 102°C. Water or steam pipes are installed above the beds of crop and along the side wall. The steam system is cheaper than hot water system. To reduce the length of pipe to be used a number of hot water or steam pipe coils can be used and green house air circulated over them by blower for heating.

b. Unit heaters
These are localized system of heating and a number of unit heaters are to be provided in the greenhouse at a height of about 3 meter to distribute heat evenly in the greenhouse. In a unit heater the fuel is combusted in the chamber at bottom. Hot fumes rise inside the heat exchanger tubes, giving heat to the walls of the tubes. Smoke exists at the top. A fan forces cool air of the greenhouse over the outside of heat exchange tubes, where it picks up heat.

c. Infra-red heaters
The fuel gas (LPG) is burnt and the fumes at a temperature of about 480°C are passed in 10 cm diameter pipes kept overhead at a height of 1.5m above plants. Reflectors are provided over the full length of pipe to radiate the infra red rays over the plants. The plants and soil only get heated without much heating of air. The infra red heating pipes can be provided at 6 to 10 meters interval all along the length of greenhouse. The temperature of fume gases at exist is about 65°C and exhaust fan is provided for maintaining the flow of fumes.

d. Solar heating
Flat plate solar heaters are used to heat the water during day time. The hot water is stored in the insulated tanks. The hot water is circulated in pipes provided along the length of the greenhouse during night. Supplementary or emergency heating systems are provided for heating the greenhouse during cloudy or rainy days.

5.3 Environmental control

5.3.1 Temperature control
The thermostat can be coupled to water circulating pump or exhaust fan for controlling the temperature inside the greenhouse. However, the lowest achievable temperature in fan and pad greenhouse is not below the wet bulb temperature in any case.

5.3.2 Relative humidity control
The humidistat coupled to water circulating pump or exhaust fan to control the relative humidity inside the fan and pad greenhouse. The maximum achievable relative humidity is 90% only in fan regulated (FR) greenhouse. The RH in Non ventilated (NV) GH can be increased by providing fogggers.

5.3.3 Light intensity control
In certain areas where natural illumination is absent or very low, illumination for plants may be provided by artificial sources. Incandescent bulbs generate excessive heat and are unsatisfactory in most instances. Fluorescent tubes are useful as the sole source of light for African violets, gloxinias and many foliage plants which grow satisfactorily at low light intensities. Excessive light intensity destroys chlorophyll even though the synthesis of this green pigment in many plants is dependent upon light. Chrysanthemum is a classic example for a short-day plant., however, flower buds will not form unless the night temperature is high enough. Chrysanthemum is flowered on a year-round basis as a cut flower or potted plant simply by controlling the length of day and temperature.

5.4 Fan and pad

5.4.1 Selection of fan
The fans should deliver the required air at 15mm static pressure. The maximum center to center spacing between the tow fans should be of 7.5m. The height of the fans is to be determined based on the plant height which is proposed to be grown in the greenhouse. The fan blades and frame are to be made of non-corrosive materials like aluminium/stainless steel.

6. Media preparation and fumigation
Soil mixes used for greenhouse production of potted plants and cut flowers are highly modified mixtures of soil, organic and inorganic materials. When top soil is included as a portion of the mixture, it is generally combined with other materials to improve the water holding capacity and aeration of the potting soil. Many greenhouses do not use topsoil as an additive to the soil mixes, but rather use a combination of these organic and inorganic components as an artificial soil mix. When managed properly as to watering and fertilization practices, these artificial mixes grow crops that are equal to those grown in top soil.
6.1 Media preparation for greenhouse production
The media used in greenhouse generally have physical and chemical properties which are distinct from field soils.
- A desirable medium should be a good balance between physical properties like water holding capacity and porosity.
- The medium should be well drained.
- Medium which is too compact creates problems of drainage and aeration which will lead to poor root growth and may harbour disease causing organisms.
- Highly porous medium will have low water and nutrient holding capacity, affects the plant growth and development.
- The media reaction (pH of 5.0 to 7.0 and the soluble salt (EC) level of 0.4 to 1.4 dS/m is optimum for most of the greenhouse crops).
- A low media pH (<5.0) leads to toxicity of micronutrients such as iron, zinc, manganese and copper and deficiency of major and secondary nutrients while a high pH (>7.5) causes deficiency of micronutrients including boron.
- A high pH of the growth media can be raised to a desired level by using amendments like lime (calcium carbonate) and dolomite (Ca-Mg carbonate) and basic, fertilizers like calcium nitrate, calcium cyanamide, sodium nitrate and potassium nitrate.
- It is essential to maintain a temperature of the plug mix between 70 to 75ºF. Irrigation through mist is a must in plug growing. Misting for 12 seconds every 12 minutes on cloudy days and 12 seconds every 6 minutes on sunny days is desirable.
- The pH of water and mix should be monitored regularly.

6.2 Desirable nutrient level in greenhouse growth media (Table 2)
Table 2: Detail of nutrient level in greenhouse.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Category</th>
<th>Concentration (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Young pot &amp; foliage plants</td>
<td>NO3: 50, N: 90, P: 6-10, K: 150-200</td>
</tr>
</tbody>
</table>

6.3 Media ingredients and Mix
Commercially available materials like peat, sphagnum moss, vermiculite, perlite and locally available materials like sand, red soil, common manure/compost and rice husk can be used in different proportions to grow greenhouse crops. These ingredients should be of high quality to prepare a good mix. They should be free from undesirable toxic elements like nickel, chromium, cadmium, lead etc.

6.4 Pasteurization of greenhouse plant growing media[3,6,7]
Greenhouse growing medium may contain harmful disease causing organisms, nematodes, insects and weed seeds, so it should be decontaminated by heat treatment or by treating with volatile chemicals like methyl bromide, chloropicrin etc (Table 3 and 4).

Table 3: Chemical pasteurization effect on greenhouse.

<table>
<thead>
<tr>
<th>Agent</th>
<th>Method</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat</td>
<td>Steam</td>
<td>30 min at 180° F</td>
</tr>
<tr>
<td>Methyl bromide</td>
<td>10 ml/cu. ft. of medium</td>
<td>Cover with gas proof cover for 24-48 hour. Aerate for 24-28 hour before use.</td>
</tr>
<tr>
<td>Chloropicrin</td>
<td>(Tear gas) 3-5 ml/cu. ft. of medium</td>
<td>Cover for 1-3 days with gas proof cover after sprinkling with water. Aerate for 14 days or until no odor is detected before using.</td>
</tr>
<tr>
<td>Basamid</td>
<td>8.0 g/cu.ft. of medium</td>
<td>Cover for 7 days with gas proof cover and aerate for at least a week before use.</td>
</tr>
<tr>
<td>Formalin</td>
<td>20 ml/l of water (37%)</td>
<td>Apply 2 l/cu.ft. cover for 14 to 36 hour and aerate for at least 14 days.</td>
</tr>
</tbody>
</table>

Disinfection of the growing media can also be achieved by fungicides or bactericides.

Table 4: Fungicides and their effect on a few fungi.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Rate of application</th>
<th>Effect against</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captan</td>
<td>2 g/l of water</td>
<td>Pythium, Fusarium, Rhizoctonia and Phytophthora. Some extent to root and stem rot, white mold, black rot, crown rot and damping off.</td>
</tr>
<tr>
<td>Metalaxyl + Mancozeb (Ridomil MZ 72 WP)</td>
<td>1 g/l of water</td>
<td>Pythium, Phytophthora, Fusarium and other soil borne pathogens</td>
</tr>
</tbody>
</table>
6.5 Temperature necessary to kill soil pests
- 115°F for water molds (Pythium and Phytophthora).
- 120°F for nematodes.
- 135°F for worms, slugs and centipedes.
- 140°F for most plant pathogenic bacteria.
- 160°F for soil insects.
- 180°F for most of weed seeds.
- 200°F for few resistant weed seeds and plant viruses.

6.6 Fumigation in greenhouse
Physical propagation facilities such as the propagation room, containers, flats, knives, working surface, benches etc. can be disinfected using one part of formalin in fifty parts of water or one part sodium hypochlorite in nine parts of water. An insecticide such as dichlorvos sprayed regularly will take care of the insects present if any. Care should be taken to disinfect the seed or the planting materials before they are moved into the greenhouse with a recommended seed treatment chemical for seeds and a fungicide –insecticide combination for cuttings and plugs respectively. Disinfectant solution such as trisodium phosphate or potassium permanganate placed at the entry of the greenhouse would help to get rid off the pathogens from the personnel entering the greenhouses.

7. Drip irrigation and fertigation systems in greenhouse cultivation
The plant is required to take up very large amounts of water and nutrients, with a relatively small root system, and manufacture photosynthates for a large amount of flower per unit area with a foliar system relatively small in relation to required production.

7.1 Watering system[6]
Micro irrigation system is the best for watering plants in a greenhouse. Micro sprinklers or drip irrigation equipments can be used. Basically the watering system should ensure that water does not fall on the leaves or flowers as it leads to disease and scorching problems. In micro sprinkler system, water under high pressure is forced through nozzles arranged on a supporting stand at about 1 feet height. This facilitates watering at the base level of the plants.

Equipments required for drip irrigation system include:
1. A pump unit to generate 2.8kg/cm2 pressure.
2. Water filtration system – sand/silica/screen filters.
3. PVC tubing with dripper or emitters.
4. Drippers of different types are available.
5. Labyrinth drippers.
6. Turbo drippers.
7. Pressure compensating drippers – contain silicon membrane which assures uniform flow rate for years.
8. Button drippers- easy and simple to clean. These are good for pots, orchards and are available with side outlet/top outlet or micro tube out let.

In fertigation system an automatic mixing and dispensing unit is installed which consists of three systems pump and a supplying device. The fertilizers are dissolved separately in tanks and are mixed in a given ratio and supplied to the plants through drippers.

8.1 Fertilizers
Fertilizer dosage has to be dependent on growing media. Soilless mixes have lower nutrient holding capacity and therefore require more frequent fertilizer application. Essential elements are at their maximum availability in the pH range of 5.5 to 6.5. In general Micro elements are more readily available at lower pH ranges, while macro elements are more readily available at pH 6 and higher.

8.2 Forms of inorganic fertilizers
Dry fertilizers, slow release fertilizer and liquid fertilizer are commonly used in green houses.

a. Slow release fertilizer
They release the nutrient into the medium over a period of several months. These fertilizer granules are coated with porous plastic. When the granules become moistened the fertilizer inside is released slowly into the root medium. An important thing to be kept in mind regarding these fertilizers is that, they should never be added to the soil media before steaming or heating of media. Heating melts the plastic coating and releases all the fertilizer into the root medium at once. The high acidity would burn the root zone.

b. Liquid fertilizer
These are 100 per cent water soluble. These comes in powdered form. This can be either single nutrient or complete fertilizer. They have to be dissolved in warm water.

8.3 Fertilizer Application Methods[4,6,7]

1. Constant Feed
Low concentration at every irrigation are much better. This provides continuous supply of nutrient to plant growth and results in steady growth of the plant. Fertilization with each watering is referred as fertigation.

2. Intermittent application
Liquid fertilizer is applied in regular intervals of weekly, biweekly or even monthly. The problem with this is wide variability in the availability of fertilizer in the root zone. At the time of application, high concentration of fertilizer will be available in the root zone and the plant immediately starts absorbing it. By the time next application is made there will be low or non existent. This fluctuation results in uneven plant growth rates, even stress and poor quality crop.

8.4 Fertilizer Injectors
This device inject small amount of concentrated liquid fertilizer directly into the water lines so that green house crops are fertilized with every watering.
8.5 Multiple injectors
Multiple injectors are necessary when incompatible fertilizers are to be used for fertigation. Incompatible fertilizers when mixed together as concentrates form solid precipitates. This would change nutrient content of the stock solution and also would clog the siphon tube and injector. Multiple injectors would avoid this problem. These injectors can be of computer controlled H.E. ANDERSON is one of the popular multiple injector.

9. Plant growing structures/containers in greenhouse production
The duration of crop in greenhouse is the key to make the greenhouse technology profitable or the duration of production in greenhouses should be short. In this context, use of containers in greenhouse production assumes greater significance. The containers are used for the following activities in greenhouse production.
• Raising of seedlings in the nursery.
• Growing plants in greenhouses for hybrid seed production of flowers.
• Growing plants for cutflower production.
• Growing potted ornamental plants.

10. Postharvest handling practices for important cut flowers
a. Rose
Roses must be placed in a bucket of water inside the polyhouse immediately after harvesting and transported to cold storage (2-4°C). The length of time depends upon the variety and quality of the roses. The flowers are graded according to the length. It varies from 40-70 cm depending on the variety and packed in 10/12 per bunch.

b. Carnation
After harvest, the flower stems have to be trimmed at the base and should be immediately placed in a bucket of preservative solution of warm and deionized water. A good preservative solution for carnations should be acidic (pH 4.5) with 2-5% sucrose and a biocide not phytotoxic to carnations. After keeping in preservative solution for 2 to 4 hours, flowers should be placed in a refrigerated room at 0-2°C for 12-24 hours. The flowers can be stored for two to four weeks before marketing. For this, the flowers have to be packed in cartons lined with polyethylene film. These cartons should have sufficient vent holes. The full cartons should be pre-cooled with out lid. The plastic is then loosely folded on top of the stems and the lid is closed. These cartons are stored in cool chambers designed to maintained 0°C with good air circulation and a constant relative humidity of 90-95%.

c. Chrysanthemum
After harvest, the stem have to be cut at equal length (90 cm is the standard), bunched in five putting a rubber band at the base and sliding them into a plastic sleeve and putting the bunches in plastic buckets filled with water. Early morning on the day of shipment (or night before) the bunches can be packed in boxes.

d. Gerbera
Harvesting is done when outer 2-3 rows of disc florets are perpendicular to the stalk. The heel for the stalk should be cut about 2-3 cm above the base and kept in fresh chlorinated water.

10.1. Storage and Packaging
Since most orchid flowers are long-lived on the plants, they should not be harvested until needed. If these are to be cut they should be stored at 5-7°C. At this temperature most orchid flowers can be stored for 10 to 14 days. Plastic film storage is attractive and can be utilized. Packaging is another important aspect in the flower trade. An ideal package should be airtight, water proof, strong enough to withstand handling and small in volume. Many ways are followed to pack orchid flowers. Cymbidium spikes are often packed 100 flowers to a box. Standard florist boxes are used for the packing of Cattleya floors. Hawaiin Dendrobium is packed in 4 dozen sprays per box. Keeping of a wet cotton at the cut end of the flower stem which is wrapped with a polythene wrapper helps to maintain humidity.

10.2. Advantages of containers in greenhouse production
• Increase in production capacity by reducing crop time.
• High quality of the greenhouse product.
• Uniformity in plant growth with good vigour.
• Provide quick take off with little or no transplanting shock.
• Easy maintenance of sanitation in greenhouse.
• Easy to handle, grade and shift or for transportation.
• Better water drainage and aeration in pot media.
• Easy to monitor chemical characteristics and plant nutrition with advanced irrigation systems like drips.

Table 5: Advantages and disadvantages of plant growing containers

<table>
<thead>
<tr>
<th>Containers</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay pot</td>
<td>Low cost Easy water management</td>
<td>Slow to work with pots and dry out fast They are heavy to handle</td>
</tr>
<tr>
<td>Fiber block</td>
<td>Easy to handle</td>
<td>Slow root penetration Short life</td>
</tr>
<tr>
<td>Fiber tray</td>
<td>Minimum use of space</td>
<td>Hard to handle when wet</td>
</tr>
<tr>
<td>Single peat</td>
<td>No media preparation</td>
<td>Requires individual handling Limited sizes can be handled</td>
</tr>
<tr>
<td>Pallet</td>
<td>Low storage requirement</td>
<td></td>
</tr>
</tbody>
</table>
Prespaced Peat pallet
Single peat Pot
Strip peat pot Protrays
Plastic pack Plastic pot Polyurethane foam
Soil band Soil block Perforated
Plastic tray Perforated Polyethylene

<table>
<thead>
<tr>
<th>Prespaced Peat pallet</th>
<th>No media preparation</th>
<th>Limited to small sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single peat Pot</td>
<td>Good root penetration</td>
<td>Difficult to separate</td>
</tr>
<tr>
<td>Strip peat pot</td>
<td>Good root penetration</td>
<td>Slow to separate</td>
</tr>
<tr>
<td>Protrays</td>
<td>Easy to handle</td>
<td>Reusable</td>
</tr>
<tr>
<td>Plastic pack</td>
<td>Easy to handle</td>
<td>Roots may grow out of container</td>
</tr>
<tr>
<td>Plastic pot</td>
<td>Reusable Good root penetration</td>
<td>Requires handling as single plant</td>
</tr>
<tr>
<td>Polyurethane foam</td>
<td>Easy to handle Requires less medium Reusable</td>
<td>Requires regular fertilization</td>
</tr>
<tr>
<td>Soil band</td>
<td>Good root penetration</td>
<td>Requires extensive labour</td>
</tr>
<tr>
<td>Soil block</td>
<td>Excellent root penetration</td>
<td>Expensive machinery</td>
</tr>
<tr>
<td>Perforated</td>
<td>Easy to handle</td>
<td>Requires regular fertigation</td>
</tr>
<tr>
<td>Plastic tray</td>
<td>Requires less medium Available in many sizes reusable</td>
<td>Roots may grow out of the container</td>
</tr>
<tr>
<td>Perforated</td>
<td>Less expensive</td>
<td>Less durable</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>Reusable bags</td>
<td>Requires less storage space</td>
</tr>
</tbody>
</table>

11. CONCLUSIONS

Poly-house cultivation is still a new and emerging trend for growing vegetables/flowers. There is always a huge and sustained demand of fresh vegetables and flowers all around the year. A particular vegetable can be grown in one season only. It cannot be grown in the next season. Therefore, to facilitate the production in off-season also, polyhouse cultivation is being done in various parts of the world. A polyhouse is a framed structure of polythene sheets in which vegetable crops can be grown under sufficiently controlled environmental conditions. One can walk easily to carry out operations under it. The size of the polyhouse is determined by the choice of the crops to be raised, i.e. either for nursery preparation or for crop cultivation. Depending upon the costs involved in the construction, the polyhouses are of three types, i.e. low-cost, medium cost and high cost. The low-cost polyhouse is made of a supporting structure of G.I. Pipe, angle iron, steel tubing. For covering, U.V. stabilized plastic film of 200 micron thickness is used. It doesn't have any control system. The medium-cost polyhouse has a cooling and a heating arrangement and may have a double layer of U.V. stabilized plastic film. The high-cost poly house has many facilities like auto control mechanism, heating, cooling and humidification system, drip irrigation system, etc.

ACKNOWLEDGEMENTS

I am grateful to SRMS, CET Management for encouragement. Special thanks are due to Professor MD Kharya for his helpful comments.

REFERENCES