**Lecture 28 Overview of Greenhouse and Basic Concept**

**28.1   Advantages, Importance, World Scenario and Status in India**

A greenhouse is a framed or an inflated structure covered with a transparent or translucent material in which crops could be grown under the conditions of at least partially controlled environment and which is large enough to permit persons to work within it to carry out cultural operations. After the advent of green revolution, more emphasis is laid on the quality of the product along with the quantity of production to meet the ever- growing food requirements. Both these demands can be met when the environment for the plant growth is suitably controlled. The need to protect the crops against unfavorable environmental conditions led to the development of protected agriculture. Greenhouse is the most practical method of achieving the objectives of protected agriculture, where the natural environment is modified by using sound engineering principles to achieve optimum plant growth and yields.

The following are the advantages of using the greenhouse for growing crops under controlled environment:

1. Throughout the year four to five crops can be grown in a greenhouse due to availability of required plant environmental conditions.

2. The productivity of the crop is increased considerably.

3. Superior quality produce can be obtained as they are grown under suitably controlled environment.

4. Gadgets for efficient use of various inputs like water, fertilizers, seeds and plant protection chemicals can be well maintained in a green house.

5. Effective control of pests and diseases is possible as the growing area is enclosed.

6. Percentage of germination of seeds is high in greenhouses.

7. The acclimatization of plantlets of tissue culture technique can be carried out in a greenhouse.

8. Agricultural and horticultural crop production schedules can be planned to take advantage of the market needs.

9. Different types of growing medium like peat mass, vermiculate, rice hulls and compost that are used in intensive agriculture can be effectively utilized in the greenhouse.

10. Export quality produce of international standards can be produced in a greenhouse.

11. When the crops are not grown, drying and related operations of the harvested produce can be taken up utilizing the entrapped heat.

12. Greenhouses are suitable for automation of irrigation, application of other inputs and environmental controls by using computers and artificial intelligence techniques.

13. Self-employment for educated youth on farm can be increased.

**Greenhouses – World Scenario**

There are more than 50 countries now in the world where cultivation of crops in the greenhouse is undertaken on a commercial scale. United States of America has a total area of about 4000 ha under  greenhouses mostly  used for floriculture with a turnover of more than  2.8 billion US $ per annum and the area under greenhouses is expected to go up considerably, if the cost of transportation of vegetables from neighboring countries continues to rise. The area under greenhouses in Spain has been estimated to be around 25,000 ha and Italy 18,500 ha used mostly for growing vegetable  crops like watermelon, capsicum, strawberries, beans, cucumbers and tomatoes. In Spain simple tunnel type greenhouses are generally used without any elaborate environmental control equipments mostly using UV stabilized polyethylene film as cladding material.

In Canada the greenhouse industry caters both to the flower and off-season vegetable markets. The main vegetable crops grown in Canadian greenhouses are tomato, cucumbers and capsicum. Hydroponically grown greenhouse vegetables in Canada find greater preference with the consumers and could be priced as much as twice the regular greenhouse produce. The Netherlands is the traditional exporter of greenhouse grown flowers and vegetables all over the world. With about 89,600 ha under cover, the Dutch greenhouse industry is probably the most advanced in the world. Dutch greenhouse industry, however, relies heavily on glass framed greenhouses, in order to cope up with very cloudy conditions prevalent all the year round. A very strong research and development component has kept the Dutch industry in the forefront. The development of greenhouses in Gulf countries is primarily due to the extremity in the prevailing climatic conditions.

Israel is the largest exporter of cut flowers and has wide range of crops under greenhouses (15,000 ha) and Turkey has an area of 10,000 ha under cover for cultivation of cut flowers and vegetables. In Saudi Arabia cucumbers and tomatoes are the most important crops contributing more than 94% of the total production. The most common cooling method employed in these areas is evaporative cooling.

Egypt has about 1000 ha greenhouses consisting mainly of plastic covered tunnel type structures. Arrangements for natural ventilation are made for regulation of temperature and humidity conditions. The main crops grown in these greenhouses are tomatoes, cucumbers, peppers, melons and nursery plant material.

In Asia, China and Japan are the largest users of greenhouses. The development of greenhouse technology in China has been faster than in any other country in the world. With a modest beginning in late seventies, the area under greenhouses in China has increased to 48,000 ha in recent years. Out of this 11,000 ha is under fruits like grapes, cherry, Japanese persimon, fig, loquot, lemon and mango. The majority of greenhouses use local materials for the frame and flexible plastic films for glazing. Most of the greenhouses in China are reported to be unheated and use straw mats to improve the heat retention characteristics.

Japan has more than 40,000 ha under greenhouse cultivation of which nearly 7500 ha is devoted to only fruit orchards. Greenhouses in Japan are used to grow wide range of vegetables and flowers with a considerable share of vegetable demand being met from greenhouse production. Even a country like South Korea has more than 21,000 ha under greenhouses for production of flowers and fruits. Thus, greenhouses permit crop production in areas where winters are severe and extremely cold as in Canada and USSR, and also permit production even in areas where summers are extremely intolerable as in Israel, UAE, and Kuwait. Greenhouses in Philippines make it possible to grow crops inspite of excessive rains and also in moderate climates of several other countries. Thus, in essence greenhouse cultivation is being practiced and possible in all types of climatic conditions.

**Status in India**

While greenhouses have existed for more than one and a half centuries in various parts of the world, in India use of greenhouse technology started only during 1980’s and it was mainly used for research activities. This may be because of our emphasis, so far had been on achieving self-sufficiency in food grain production. However, in recent years in view of the globalization of international market and tremendous boost and fillip that is being given for export of agricultural produce, there has been a spurt in the demand for greenhouse technology. The National Committee on the use of Plastics in Agriculture (NCPA-1982) has recommended location specific trials of greenhouse technology for adoption in various regions of the country. Greenhouses are being built in the Ladakh region for extending the growing season of vegetables from 3 to 8 months. In the North-East, greenhouses are being constructed essentially as rain shelters to permit off-season vegetable production. In the Northern plains, seedlings of vegetables and flowers are being raised in the greenhouses either for capturing the early markets or to improve the quality of the seedlings. Propagation of difficult-to-root tree species has also been found to be very encouraging. Several commercial floriculture ventures are coming up in Maharashtra, Tamil Nadu and Karnataka states to meet the demands of both domestic and export markets. The commercial utilization of greenhouses started from 1988 onwards and now with the introduction of Government’s liberalization policies and developmental initiatives, several corporate houses have entered to set up 100% export oriented units. In just four years, since implementation of the new policies in 1991, 103 projects with foreign investment of more than Rs.80 crores have been approved to be set up in the country at an estimated cost of more than Rs.1000 crores around Pune, Bangalore, Hyderabad and Delhi. Thus the area under climatically controlled greenhouses of these projects is estimated to be around 300 ha. Out of which many have already commenced exports and have received very encouraging results in terms of the acceptance of the quality in major markets abroad and the price obtained.

**Source:** http://en.wikipedia.org/wiki/Greenhouse

              http://www.vedamsbooks.in/no105062/cart.php

**28.2 Constituents of Environment in Greenhouse- Natural Light, Artificial Source of Light, Solar Radiation, Temperature, Humidity, Carbon Dioxide**

The productivity of a crop is influenced not only by its heredity but also by the microclimate around it. The components of crop microclimate are light, temperature, air compositions and the nature of the root medium. In open fields, only manipulation of nature of the root medium by tillage, irrigation and fertilizer application is possible. The closed boundaries in greenhouse permit control of any one or more of the components of the micro climate.

**Light**

The visible light of the solar radiation is a source of energy for plants. Light energy, carbon dioxide (CO2) and water all enter in to the process of photosynthesis through which carbohydrates are formed. The production of carbohydrates from carbon dioxide and water in the presence of chlorophyll, using light energy is responsible for plant growth and reproduction. The rate of photosynthesis is governed by available fertilizer elements, water, carbon dioxide, light and temperature. Considerable energy is required to reduce the carbon that is combined with oxygen in CO2 gas to the state in which it exists in the carbohydrate. The light energy thus utilized is trapped in the carbohydrate. If the light intensity is diminished, photosynthesis slows down and hence the growth. If higher than optimal light intensities are provided, growth again slows down because of the injury to the chloroplasts. The light intensity is measured by the international unit known as Lux. It is direct illumination on the surrounding surface that is one meter from a uniform point source of 1 international candle. Greenhouse crops are subjected to light intensities varying from 129.6 klux on clear summer days to 3.2 klux on cloudy winter days. For most crops, neither condition is ideal. Many crops become light saturated, in other words, photosynthesis does not increase at light intensities higher than 32.2 klux. Rose and carnation plants will grow well under summer light intensities. In general, for most other crops foliage is deeper green if the greenhouse is shaded to the extent of about 40% from mid spring (May) to mid fall (August and September). Thus, it is apparent that light intensity requirements of photosynthesis are vary considerably from crop to crop.

Light is classified according to its wave length in nanometers (nm). Not all light is useful in photosynthesis process. UV light is available in the shorter wavelength range, i.e. less than 400nm. A large quantity of it is harmful to the plants. Glass screens are opaque to the most UV light and light below the range of 325nm. Visible and white light has wavelength of 400 to 700nm. Far red light (700 to 750nm) affects plants, besides causing photosynthesis. Infrared rays of longer wavelengths are not involved in the plant process. It is primarily, the visible spectrum of light that is used in photosynthesis. In the blue and red bands, the photosynthesis activity is higher, when the blue light (shorter wavelength) alone is supplied to plants, the growth is retarded, and the plant becomes hard and dark in colour. When the plants are grown under red light (longer wavelength), growth is soft and internodes are long, resulting in tall plants. Visible light of all wavelengths is readily utilized in photosynthesis. The intensity of sunlight required by different plants is different. If plant requires shade, a shade net can be used which allows around 30 to 50% of sunlight to pass through it. UV stabilized polythene sheets have transmittance value of 88% (single layer), 77% for double layer.

**Temperature**

Incoming solar radiation has shorter wavelength and hence greater energy. After penetrating through the polythene sheet this radiation strikes the earth. Earth absorbs some energy thus converting radiation of shorter wavelength to longer wavelength radiation. Hence the outgoing radiation has longer wavelength. Longer wavelengths are trapped inside the Greenhouse that causes increase in the temperature. This is beneficial during winter month.

To reduce temperature during summer months, polyethylene can be removed or shade net is used to allow only some percentage of sunlight to pass through. Misters and micro sprinklers are also used to reduce inside temperature. In sub-humid climate temperature maintained inside a Greenhouse is between 30 and 370 C.

Temperature is a measure of level of the heat present. All crops have temperature range in which they can grow well. Below this range, the plant life process stop due to ice formation within the tissue and cells are possibly punctured by ice crystals. At the upper extreme, enzymes become inactive, and again process essential for life cease. Enzymes are biological reaction catalyst and are heat sensitive. All biochemical reactions in the plant are controlled by the enzymes. The rate of reactions controlled by the enzyme often double or triple for each rise of temperature by 100C, until optimum temperature is reached. Further, increase in temperature begins to suppress the reaction and finally stop it. As a general rule, greenhouse crops are grown at a day temperature, which are 3 to 60C higher than the night temperature on cloudy days and 80C higher on clear days. The night temperature of greenhouse crops is generally in the range of 7 to 210C.

**Humidity**

As the greenhouse is a closed space, the relative humidity of the greenhouse air will be more when compared to the ambient air, due to the moisture added by the evapo-transpiration process. Some of this moisture is taken away by the air leaving from the greenhouse due to ventilation. Sensible heat inputs also lower the relative humidity of the air to some extent. In order to maintain the desirable relative humidity levels in the green houses, processes like humidification or dehumidification are carried out. For most crops, the acceptable range of relative humidity is between 50 to 80%. However for plant propagation work, relative humidity up to 90% may be desirable. In summer, due to sensible heat addition in the daytime, and in winters for increasing the night time temperatures of the greenhouse air, more sensible heat is added causing a reduction in the relative humidity of the air. For this purpose, evaporative cooling pads and fogging system of humidification are employed. When the relative humidity is on the higher side, ventilators, chemical dehumidifiers and cooling coils are used for de- humidification. Inside a Greenhouse humidity should always be greater than 50%. To increase the humidity various accessories are used like, sprinklers, misters, water coolers with fans. Hygrometer is fixed inside the greenhouse to check the humidity inside.

**Air Circulation**

A greenhouse is ventilated for either reducing the temperature of the greenhouse air or for replenishing carbon dioxide supply or for moderating the relative humidity of the air. Air temperatures above 350C are generally not suited for the crops in green house. It is quite possible to bring the greenhouse air temperature below this upper limit during spring and autumn seasons simply by providing adequate ventilation in the green house. The ventilation in a greenhouse can either be natural or forced. In case of small green houses (less than 6m wide) natural ventilation can be quite effective during spring and autumn seasons. However, fan ventilation is essential to have precise control of the air temperature, humidity and carbon dioxide levels. Air circulation inside a Greenhouse can be controlled either natural ventilation or by forced ventilation. The temperature difference between inside and outside air causes natural air movements. The warmer air inside is replaced by outside air through natural ventilation with the help of vents provided at the top of the roof. In forced ventilation fans are used for forced air circulation.

**Greenhouse ventilation**

Ventilation is the process of allowing the fresh air to enter into the enclosed area by driving out the air with undesirable properties. In the greenhouse context, ventilation is essential for reducing temperature, replenishing CO2 and controlling relative humidity. Ventilation requirements for green houses vary greatly, depending on the crop grown and the season of production. The ventilation system can be either a passive system (natural ventilation) or an active system (forced ventilation) using fans. Usually greenhouses that are used seasonally employ natural ventilation only. The plant response to specific environment factor is related to the physiological processes and hence affects the yield and quality. Hence, controlling of environment is of great importance to realize the complete benefit of CEA. Manual maintenance of uniform environmental condition inside the greenhouse is very difficult and cumbersome. A poor maintenance results in less crop production, low quality and low income. For effective control of automatic control systems like micro processor and computer are used to maintain the environment.

**Natural ventilation**

In the tropics, the sides of greenhouse structures are often left open for natural ventilation. Tropical greenhouse is primarily a rain shelter, a cover of polyethylene over the crop to prevent rainfall from entering the growing area. This mitigates the problem of foliage diseases. Ventilators were located on both roof slopes adjacent to the ridge and also on both side walls of the greenhouse. The ventilators on the roof as well as those on the side wall accounts, each about 10% of the total roof area. During winter cooling phase, the south roof ventilator was opened in stages to meet cooling needs. When greater cooling was required, the north ventilator was opened in addition to the south ventilator. In summer cooling phase, the south ventilator was opened first, followed by the north ventilator. As the incoming air moved across the greenhouse, it was warmed by sunlight and by mixing with the warmer greenhouse air. With the increase in temperature, the incoming air becomes lighter and rises up and flows out through the roof ventilators. This sets up a chimney effect, which in turn draws in more air from the side ventilators creating a continuous cycle. This system did not adequately cool the greenhouse. On hot days, the interior walls and floor were frequently injected with water to help cooling.

**Forced Ventilation**

In forced or active ventilation, mechanical devices such as fans are used to expel the air. This type of ventilation can achieve uniform cooling. These include summer fan-and-pad and fog cooling systems and the winter convection tube and horizontal airflow systems. For mechanical ventilation, low pressure, medium volume propeller blade fans, both directly connected and belt driven are used for greenhouse ventilation. They are placed at the end of the greenhouse opposite to the air intake, which is normally covered by gravity or motorized louvers. The fans vents, or louvers, should be motorized, with their action controlled by fan operation. Motorized louvers prevent the wind from opening the louvers, especially when heat is being supplied to the green house. Wall vents should be placed continuously across the end of the greenhouse to avoid hot areas in the crop zone. Evaporative cooling in combination with the fans is called as fan-and-pad cooling system. The fans and pads are usually arranged on opposite walls of the greenhouse. The common types of cooling pads are made of excelsior (wood fiber), aluminum fiber, glass fiber, plastic fiber and cross-fluted cellulose material. Evaporative cooling systems are especially efficient in low humidity environments. There is growing interest in building greenhouses combining both passive (natural) and active (forced) systems of ventilation. Passive ventilation is utilized as the first stage of cooling, and the fan-pad evaporative cooling takes over when the passive system is not providing the needed cooling. At this stage, the vents for natural ventilation are closed. When both options for cooling are designed in greenhouse construction, initial costs of installation will be more. But the operational costs are minimized in the long run, since natural ventilation will, most often meet the needed ventilation requirements. Fogging systems is an alternative to evaporative pad cooling. They depend on absolutely clean water, Free of any soluble salts, in order to prevent plugging of the mist nozzles. Such cooling systems are not as common as evaporative cooling pads, but when they become more cost competitive, they will be adopted widely. Fogging systems are the second stage of cooling when passive systems are inadequate.

**Carbon Dioxide**

Carbon is an essential plant nutrient and is present in the plant in greater quantity than any other nutrient. About 40% of the dry matter of the plant is composed of carbon. Under normal conditions, carbon dioxide (CO2) exits as a gas in the atmosphere slightly above 0.03% or 345ppm. During the day, when photosynthesis occurs under natural light, the plants in a greenhouse draw down the level of CO2 to below 200ppm. Under these circumstances, infiltration or ventilation increases carbon dioxide levels,when the outside air is brought in, to maintain the ambient levels of CO2. If the level of CO2 is less than ambient levels, CO2 may retard the plant growth. In cold climates, maintaining ambient levels of CO2 by providing ventilation may be un- economical, due to the necessity of heating the incoming air in order to maintain proper growing temperatures. In such regions, enrichment of the greenhouse with CO2 is followed. The exact CO2 level needed for a given crop will vary, since it must be correlated with other variables in greenhouse production such as light, temperature, nutrient levels, cultivar and degree of maturity. Most crops will respond favorably to CO2 at 1000 to 1200 ppm.

**28.3 Working principle**

A greenhouse uses a special kind of covering material that acts as a medium which selectively transmits spectral frequencies. The covering material of the greenhouse traps energy within the greenhouse and the heat in turn provides for the plants and the ground inside the greenhouse. It warms the air near the ground, preventing it from rising and leaving the confines of the structure. The sun shines enters in the greenhouse through the covering material as short waves. These waves strike objects in the greenhouse and are reradiated as long waves, the long waves do not readily return through the covering material. This is known as the greenhouse effect. The greenhouse effect is similar to hot air trapped in a car on a sunny day with the windows closed. The inside air becomes warmer than the outside air. Objects in the greenhouse such as absorb heat during the day and return it to the ambient at night.