



PROTECTED CULTIVATION OF ORNAMENTALS

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ABSTRACT

India has been identified as one of the major forces in the world floriculture scenario (Gharge *et al.*, 2011). Looking to the increasing population, climate change, decreasing land holdings, increasing pressure on natural resources *i.e.* land & water and high demand of quality produce we are forced to shift towards modern technologies of crop production like protected cultivation. In protected cultivation microclimate surrounding the plant body is controlled partially or fully as per requirement of plant (Chandra, 2001). It is rather used to protect plants from the adverse climatic conditions by providing optimum conditions of light, temperature, humidity, CO₂ and air circulation for the best growth of plants to achieve maximum yield and best quality produce. Unemployed educated youths who are not attracted or interested in traditional agriculture are also showing good interest and can be further motivated for this kind of modern agricultural technologies. Various types of protected structure are available like, greenhouse, net house, shade house, hotbeds, cold frames *etc.* Greenhouse technology is the most practical way of achieving the goal of protected cultivation (Nagarajan *et al.*, 2002). Protected cultivation also enables growers to realize greater returns per unit of land and offer other benefits like, early harvest, longer harvest duration, reduce leaching of fertilizers and eco- friendly management of pest, weed and disease (Kumar *et al.*, 2007). Protected cultivation not only increases the sustainability of agricultural production but also improves the standard of living.

KEYWORDS: floriculture, scenario, protected cultivation, pest, weed.

INTRODUCTION

As a result of globalization of trade and liberalization of Indian economy, there is an immense scope for export of high value horticultural crops from India, besides meeting the increased demand in domestic market. The need of the time is to increase the productivity and quality of produce to meet the demand of quality conscious consumers. A breakthrough in production technology that integrates market driven quality parameters with the production system, besides ensuring a vertical growth in productivity is required. One such technology is “Protected cultivation”, or generally called Greenhouse technology. Quality material, growing environment, and cultural practices are the three most important factors which determine productivity and quality of the ornamentals. Whereas control over quality of planting material and cultural practices can be fully exercised under open field cultivation, environment control is possible only under protected condition. The floriculture industry has annual growth potential of 25-30% and is capable of earning foreign exchange 20-25 times more than cereals or other agricultural crops. Despite the availability of ample natural resources for successful flower cultivation, our share in world flower trade is meagre (0.40-0.50%) (Ranjan *et al.*, 2013). This is because most of the cut flowers need to be

grown under protected conditions to meet stringent quality control regimes of global flower trade.

Protected cultivation is practiced to ensure consistency in quality and quantity required to limit the risk due to weather hazards, insect pest incidence, leading to reduction in quality production especially in open field conditions. Better quality of produce (more diameter, larger stalk, stability of color) and better keeping quality can be achieved only through protected cultivation technology. On the hills most of the crops are cultivated during summer season in open field condition but winter season is usually out of any crop. Thus protected cultivation is the only way for achieving year round cultivation. Various types of protected structures are available which are suitable for specific type of agro-climatic zones. Among these, green house, net house shade house, hot beds and cold frames are important for cultivation of ornamentals.

PROTECTED CULTIVATION

- Protected cultivation can be defined as a cropping technique where in the micro climate surrounding the plant body is controlled partially/ fully as per the requirement of the plant species grown during their period of growth (Chandra, 2001).

- Greenhouse technology is the most practical way of achieving the goal of protected cultivation. (Nagarajan *et al.*, 2002).

Principles of protected crop production

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 composition and the nature of the root medium. Under open field conditions, it is not possible to control over light, temperature and air composition. The only possibility under open-field conditions is to manipulate the nature of the root medium by tillage, irrigation, fertilizer applications *etc.* Even here, the nature of the root medium is being modified and not controlled. A greenhouse, due to its closed boundaries, permits the control over any one or more of the components of microclimate. A greenhouse is covered with a transparent or a translucent material such as glass or plastics. Depending upon its transparency, the greenhouse cover admits a major fraction of sunlight. The sunlight admitted to greenhouse is absorbed by the crop, floor, and other objects in the greenhouse. These objects in greenhouse in turn emit long wave thermal radiation for which the cover material has lower transparency, as a result, the solar energy is trapped in greenhouse raising its temperature. This phenomenon is generally known as greenhouse effect (Mishra *et al.*, 2010). It is this natural rise in the greenhouse air temperature which is utilized under cold climates to grow successful crops. The same natural phenomenon during summers, however, requires greenhouse cooling to maintain favourable temperatures. There are innumerable studies quantifying the effect of the environmental parameters individually as well as collectively on crop growth. The crop photosynthesis at

optimum levels of environmental parameters follows a significantly higher curve.

Conditions maintained in greenhouse

There are four different types of environmental parameters maintained in a Green house. These are:

1. CO₂
2. Temperature
3. Light
4. Humidity

CARBON-DI-OXIDE

In our surrounding atmosphere CO₂ conc. is 0.03% means 300ppm. Plants use this CO₂ for photosynthesis. Carbon dioxide (CO₂) enrichment of the winter greenhouse environment is a question that many growers ask. Research in northern climates has shown that raising the CO₂ level from the normal ambient level of 350-1000 ppm often results in increased yield. Effective use of this technology requires that houses be closed for long periods each day. The frequent need for ventilation of the greenhouse, even in winter in India makes CO₂ enrichment a very questionable practice. The problem is that high levels of CO₂ cannot be maintained for more than an hour or so on most days. Carbon dioxide enrichment enhances vegetative growth by 13% and reproductive output by 31% in general

Due to increased CO₂ concentration crop production time is shorter and larger stems, leaves and flowers are obtained. Some of the green house ornamentals that benefit from increased CO₂ are rose, carnation, gypsophila (increase in no. of lateral shoots) and chrysanthemum (increase in number of roots per cutting.)

Effect of CO₂ enrichment on growth and flowering of ornamentals

Crop	Concentration of CO ₂ (ppm)	Effects
Begonia	700-900	Enhanced growth rate, shorter culture Time, larger flowers and abundant flowering.
Carnation	1000-1500	Better lateral branching ,higher growth Rate of young plants, higher yield and stem quality.
Chrysanthemum	700-900	Higher relative growth rate and better flower quality.
Dieffenbachia	700-900	Faster growth
Ficus elastica	1000-1500	Larger leaves
Hibiscus	1000-1500	Earlier and number of leaves.
Petunia	1000-1500	Earlier flowering
Rose	1000-1500	Reduced no. of blind shoots, higher yield, longer and stronger flower stems

(S.K Bhattacharjee)

TEMPERATURE

Temperature management is very important for successful greenhouse crops. Poorly controlled temperature regimes can increase disease and lead to fruit colour and quality problems. According to temperature requirement plants are grouped as

Cool seasons crops *e.g.* narcissus, alstroemeria

Warm season crops *e.g.* anthurium, gerbera

Low temperature injuries have been shown in chrysanthemum (pink coloration in white flowers), rose (bull heads) and chilling injury in orchids. Leaf scorching and scalding are the effects due to higher

temperature. Temperature control is achieved by the use of various systems including heating furnaces, exhaust fans, evaporative cooling pads, and shade clothes.

LIGHT

Effect of light on plant life depends upon its quantity or intensity, quality or kind of light, and the number of day length or photoperiod. Plant vary in their requirement for light. Rose and Carnation require light of high intensity 500-1000ft. candles whereas the plants like ficus, begonia, and anthurium needs light of low intensity. Light intensity also effects leaf and flower colours are more intense or darker at higher light intensities. The

importance of providing a consistent daily light integral is becoming more widely recognized as a means to achieve steady growth and production. Light is the sole source of energy provided to plants to build tissue. Excess light is not a problem in itself but the excessive heat associated with the high radiant energy can cause high temperature problems. During these problem periods, shading of the greenhouse to be practised. Shading compounds can be painted on the outside of the house or shade cloth systems can be erected inside/outside the house. Shading can be a 2-tier system where 30-40% shade cloth is used over the house or on the inside on cables following the contour of the ceiling. The second cloth would be 10-20% shade over the trellis at plant height. Shade systems on cables have an advantage of being moveable shading can be removed during cloudy periods. Shade cloths can be made of knitted or spun bonded polypropylene for the low cost small houses. Plastics sheets are not desirable as they collect water due to condensation. During winter, lighting is provided in the form of incandescent, tungsten, halogen, and fluorescent and high intensity discharge lamps (HID) to induce flower growth during winter. However, its utility should be judged by the comparison of costs and added returns.

HUMIDITY

General requirement of humidity for most of the flower production is 65% to 80%. Because of controlled humidity plant growth remains continuous, flower grows with attractive colors and after cutting, their shelf life also increases. Higher humidity increases powdery mildew and downy mildew incidence and lower humidity could cause the desiccation harm the flower quality. A greenhouse is a closed space in which plants transpire and evaporation takes place from the floor. Some of this moisture, added to greenhouse air, is taken away by the air leaving the greenhouse due to ventilation and/or leakages. Sensible heat inputs modify the relative humidity to some extent. In order to maintain desirable relative humidity levels in greenhouses, efforts are made to use humidification or dehumidification. Humidification in summers can be achieved in conjunction with greenhouse cooling by employing appropriate evaporative cooling methods such as fan-pad and fogging systems. Sometimes during winters

when sensible heat is being added to raise the greenhouse air temperature during nights the relative humidity level might fall below the acceptable limit. In that situation, humidifiers might need to be operated to circumvent the problem. Dehumidification is often a problem not amenable to simple solutions. During rainy seasons the ambient relative humidity is high along with that of the greenhouse. In this situation the ventilation cannot lower the humidity of greenhouse air but when the ambient relative humidity is lower than ventilation could be practised to reduce the greenhouse relative humidity. Chemical dehumidification systems are technically feasible but expensive at present. Use of refrigeration systems (cooling coils) has also been made for dehumidification, but only at a smaller level.

NEED FOR PROTECTED CULTIVATION

Protected cultivation is practiced to ensure consistency in quality and quantity required to limit the risk due to weather hazardous, insect pest incidence, leading to reduction in quality production especially in open field conditions Other benefits include:-

- Better quality of produce (more diameter, larger stalk, stability of color) and better keeping quality
 - Higher production per unit area
 - Early maturity
 - Round the year cultivation through high tech green houses
 - Protection of valuable plant germplasm
 - Hardening and acclimatization of tissue cultured plants.
 - Protection from biotic and a biotic stresses
 - Barren and uncultivable land may be brought under use
 - Employment generation
 - Increased yield (4-5 times then traditional planting)
- (Devi and Thakur 2013)

Greenhouse area in different countries

Out of 800 ha area under greenhouses in India, 83 ha has been covered in the NE states, the maximum area being in Sikkim. Protected cultivation is being followed worldwide, Japan and has maximum share of around 54000 and 48000 ha under greenhouse respectively.

Country	Area (ha)	Country	Area (ha)
Japan	54000	Turkey	10000
China	48000	USA	9600
South Korea	21000	USA	4000
Spain	25000	Israel	1500
Italy	18500	India	800

(Sanwal, 2011)

PROTECTED STRUCTURES FOR PROTECTED CULTIVATION OF ORNAMENTALS

1. Green house
2. Shade house
3. Lath house
4. Cold frames
5. Hot beds

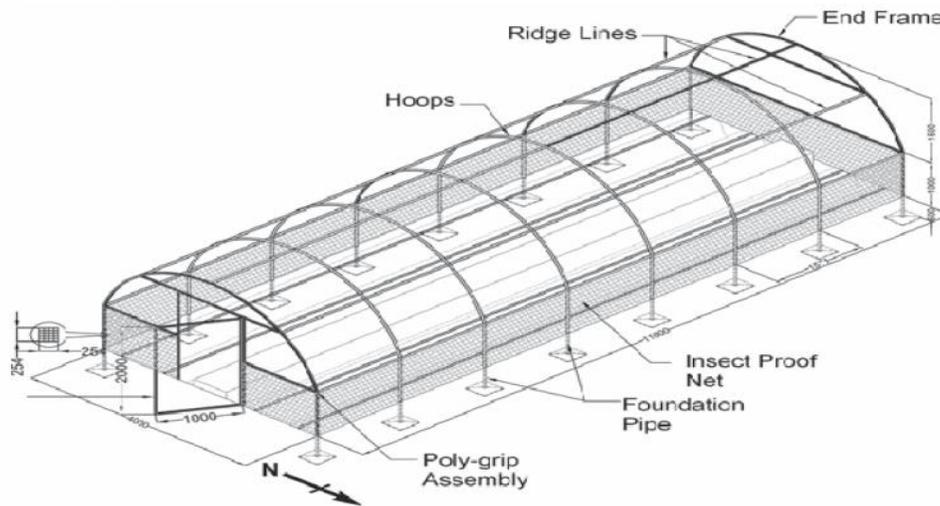
1. GREENHOUSE

A greenhouse can be defined as a “framed or an inflated structure with a transparent or translucent material in which crops could be grown under at least partially controlled environment and which is large enough to permit persons to work within it to carry out cultural operations” (Devi and Thakur 2013). The greenhouse is now better understood as a system of controlled environment agriculture (CEA), with precise control of air,

temperature, water, humidity, plant nutrition, carbon dioxide and light. The inside environment (microclimate) of the greenhouse is controlled by growth factors like light, temperature, humidity and carbon dioxide

concentration. They are scientifically controlled to an optimum level throughout the cultivation period, thus increasing the productivity by several folds.

GREENHOUSE DESIGN



CLASSIFICATION OF GREENHOUSES

Greenhouse type based on shape:

- **Lean to type greenhouse:**

This type of design is used when a greenhouse the side of is to be constructed against existing building, so that plants can make the best use of sunlight and owner can minimize the requirement of roof supports. The roof of the building is extended with appropriate greenhouse covering material and the area is properly enclosed.

- **Even span type greenhouse:**

These kinds of greenhouses are constructed in regions of India. Such small sizes are greenhouses are designed when owner is to use levelled ground. In this type greenhouse is constructed with the two roof slopes of equal pitch and width. These may be of several single and multiple span types. For single span types the span in general, varies from 5 to 9 m, whereas the length is around 24 m. the height varies from 2.5 to 4.3 m.

- **Uneven span type greenhouse:**

This type of greenhouse is constructed on hilly terrain. The roofs of the greenhouse are equal width, so that owner can make use of the side slopes of hill. They are well adoptable to the hilly region. These are not adaptable for automation.

- **Ridge and furrow type greenhouse:**

These are 'A' designed greenhouse, which are connected to one another along the length of the eave. The eave serves as a furrow or gutter to carry rain and melted snow away the sidewall is eliminated between the greenhouses, which results in a structure with a single large interior. This design reduce labour cost of automation, improves personal management and reduce fuel consumption because it has less exposed wall area through which heat escapes. While construction it is necessary to know the snow loads, which will have to select the type of frame ridge and furrow greenhouse are commonly used in

northern countries of Europe and Canada and are well suited to the Indian condition.

- **Saw tooth type greenhouse:**

The structure similar to ridge and furrow type greenhouse except that, there is provision for natural ventilation in this type. Specific natural ventilation flow path develops in saw tooth type.

- **Quonset greenhouse:**

This kind of greenhouse is constructed by using pipe arches or trusses for support. The pipe purlins run along the length of the greenhouse. The greenhouse is covered by polyethylene sheet. This kind of greenhouse provides sufficient area to plants to grow between the overlapping portions of adjacent house. This type of green house is used for the cultivation of rose.

2.GREENHOUSE TYPE BASED ON CONSTRUCTION:

- **Wooden framed structure:**

This kind of greenhouse is made with less than 6 m and only wooden framed structures are used. Side post and columns are constructed of pinewood with the use of a truss. It has required strength and less expensive. Timber locally available, with goods strength and durability can be used for the construction.

- **Pipe frame structures:**

This kind of greenhouse is made when the clear span is around 12 m. For this purpose pipes are used for the construction. In general the side posts, columns, cross ties and purlins are constructed using pipes in this type also the trusses are not used.

- **Truss frame structure:**

This kind of greenhouse is made when the greenhouses span the greater than or equal to 15 m. for this purpose truss frames are used. Flat steel, tubular steel angle iron are welded together to form a truss encompassing rafters, chord and struts .when wide truss frame house of 21.3m or

more are to be constructed, column are used. Most of the glass houses are of truss frame type, as these frames are best suited for pre-fabrication.

GREENHOUSE TYPE BASED ON THE COST OF CONSTRUCTION INVOLVED

• Low-cost 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, increased when all sidewalls are covered with plastic film. This type of greenhouse is mainly suitable for cold climatic zone.

• Medium-cost 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 favourable humidity inside the greenhouse. As these systems 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.

• High-cost greenhouse:

It is constructed on the structure (frame) made of iron/aluminums structure, designed domed-shaped or cone-shaped (as per choice). Temperature, humidity, light and dehumidification system drip irrigation system etc. are automatically controlled as per requirement of the users. Floor and a part of walls are made of concrete. It is highly durable, about 5–6 time costlier, required qualified operator, proper maintenance, care, and precautions while operating.

Cladding/covering material

Polythene proves to be an economical cladding material. Now long lasting, unbreakable and light roofing panels-UV stabilized clear fibre glass and polycarbonate panels are available. Plastics are used in tropical and sub-tropical areas compared to glass/fiberglass owing to their economic 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.

Comparison of different kinds of covering materials

S.no	Type	Durability	Transmission		Cost
			Light	Heat	
1	Poly ethylene	One year	90%	70%	Very high
2	Poly ethylene UV resistant	Two years	90%	70%	High
3	Fibre Glass	Seven years	90%	5%	Low
4	Tedlar coated Fibre Glass	Fifteen years	90%	5%	Low
5	Double Strength Glass	Fifty years	90%	5%	Low
6	Poly Carbonate	Fifty years	90%	51 %	Very Low

(www.tnau.ac.in)

SITE SELECTION FOR GREEN HOUSE:

Following things are taken into account

- The selection site should be free from pollution.
- Water should be available regularly
- Supply of electricity should be regular
- Soil should be properly leveled and drained
- Polyhouse should be near to road side means proper approachable road must be there to go to poly house
- Some space should be there nearby for further extension
- Expertise and labors should be available when required.

METHODS OF VENTILATION UNDER GREENHOUSE

- **Natural ventilation-** Providing sufficient open area in the greenhouse structure so that ambient air by itself enters into the greenhouse after displacing an equal amount of greenhouse air.

- **Forced ventilation-** Auxiliary power is used to move air through the greenhouse

Advantages of polyhouse technology

- Protection from excess rainfall, wind current, scorching sunlight and extreme cold conditions
- Under minimum space one can have maximum production of crop plants
- Humidity is maintained
- Efficient use of CO₂
- Minimum use of water and fertilizers
- A single person can have control over thousands of plants
- Diseases and pests can be controlled easily
- Production of crop throughout the year
- Protection from birds, animals and human activities
- Labor cost is reduced
- Quality of product is best

Evaluation of carnation cultivars grown under naturally ventilated poly house

Varieties	No. of branches / plant	No. of flowers/ plant	Stem length	No. of leaf pairs /stem	Flower diameter
Diana	3.66	27.00	66.30	9.00	7.30
Aurturo	5.00	23.30	69.30	9.00	7.00
White Dona	5.60	23.60	56.60	8.00	7.00
Pink Dona	7.30	29.30	53.40	10.30	6.80
Soto	5.60	24.00	62.30	9.30	6.80
Red King	8.00	35.60	75.00	9.60	7.80
Tuareg	5.33	22.00	68.30	11.00	5.70
Dona	6.60	28.00	65.50	10.60	7.50
CD 5%	1.61	10.50	14.29	1.45	0.83

(Singh *et al.*, 2013)**Comparison of peak flowering under poly house and shade house**

Months	Poly house No. of flowers/meter	Shade house No. of flower/meter
June	18	15
July	19	17
August	20	19
September	23	21
October	25	23
November	26	24
December	27	22
January	26	24
Total	184	168
Mean	23	21

(Pattnashetti, 2009)

2. Net house (shade net house):

A shade net house commonly known as conservatory or fernery, is used for keeping shade loving or partial shade loving ornamental plants e.g. ferns, orchids, anthurium alocasia, cacti, succulents and foliage plants. The material used for shading a shade house split bamboo matting,

coconut leaves or coir fibers having open inter spaces to allow partial sunlight to enter. Plastic nets like Seran, Netlon with varying percentage of cut out lights, like 80,60,40 are commercially used to provide cover and shade.

Quality parameters of flowers of gerbera cultivars grown under shade house

Cultivars	Flower diameter (cm)	Stalk length (cm)	Stalk girth (mm)	No. of ray florets
Dalma	11.0	48.5	6.7	62.0
Rosalin	12.2	49.5	6.3	49.0
Sunway	10.6	49.2	6.8	55.0
Dana Ellen	11.3	58.7	6.8	55.3
Savannah	13.7	61.9	8.7	56.0
Pink Elegance	12.4	61.0	6.3	83.0
Goliath	11.5	55.8	6.8	84.3
Fusion	9.6	49.6	5.3	50.0
Entourage	12.1	57.4	6.7	71.3
Winter Queen	12.8	59.3	6.5	57.0
LSD (p=0.05)	0.62	2.59	0.85	3.27

Patil *et al.* (2010)**1. Lath house**

Lath house are used to provide partial shade to plants like azaleas, hydrangeas during summer month in many localities. The frame is similar to that of shade houses, but the cover is movable. Lath houses are usually used to protect high light sensitive ornamental plants.

2. Cold frame

The cold frame is made with frame and the glass cover. Cold frames are used to protect plants from frosts heavy rains and heavy winds. These are used in winter for raising

herbaceous Annuals, biennials and cut flowers and nursery of other perennial plants.

3. Hot beds

The main objective of hot bed is to raise seedlings earlier and protect them from weather hazards. A hot bed is one where heat is generated by decomposition of fresh manure. The heat generated is utilized for seed germination, which results in early nursery raising and protect them from weather hazards, especially during winters. First of all a trench 2 feet deep, 3 feet wide, 6 feet long is prepared. The frame generally made of wood is filled in such a way that

from back side it extends up to 30-35 cm and from front side 20-25 cm above the ground.

Effective water management technique under polyhouse conditions:

Land and water are the two basic important natural resources, which play an important role in agriculture production. The plant must be provided with sufficient water for its existence as well as the growth. The water, air, and the sunlight with sufficient water for its existences well as the growth. The polyhouse must be near to house, where the water and electricity can supply easily. The polyhouse owner should also arrange the facility for drain and dispose the unwanted water.

Micro irrigation is essential under polyhouse conditions for the precise application of water and nutrients at frequent intervals matching with crop growth curve to achieve higher water and nutrient use efficiency. Also, reduce the infestation of insect and pest as compared to surface irrigation. A good knowledge of the basic principles that determine movement of water and salts in drip irrigation especially, under controlled conditions, influence by low flow rate and localized water application is necessary for salinity control and good water management. An efficient water use will be reached with a proper irrigation scheduling, which involves knowing the crop water requirement.

IRRIGATION METHODS UNDER PROTECTED CULTIVATION

1. Hand watering
2. Over-head Sprinkler (Water application efficiency -80-85%)
3. Drip Irrigation (Water application efficiency-90-95%)
4. Mist System

Drip irrigation

Drip irrigation is defined as the precise, slow application of water in the form of discrete or continuous or tiny streams of miniature sprays through mechanical devices called emitters or applicators located at selected points along water delivery lines. It is an efficient method of providing irrigation water directly into the soil is root zone of plants. It permits utilization of fertilizers, pesticide and other water soluble chemicals. The major advantages of drip system includes 30-70, 30-100, 40-60, and 44-47 per cent savings water, yield, fertilizer and energy, respectably. It also resulted in better crops quality, high returns per unit area, save labour cost and improved water penetration. Poor quality irrigation water can also be used safely under drip irrigation method. There are however, some disadvantages of this method such as high initial installation cost, losses of pipes due to direct effect of sun rays resulting into shortening of their usable life. Also, if the water is not properly filtered and equipment is not properly maintained then, it resulted into closing of emitters. There four type of drip irrigation system.

1. Subsurface drip irrigation system: In this system, the drippers and the lateral are laid below the ground level in the plants' root zone.

2. Surface drip irrigation system: In this system, the drippers and the laterals are laid on the soil surface.

3. On line drip irrigation system: In which the drippers or emitters are fixed on the lateral pipes by punching suitable holes on the drip lateral pipes at the locations specific to the crop being irrigated.

4. In line drip irrigation system: In which the drippers are factory installed within or on the drip lateral and are suitable for closely spaced field crops in order to achieve a continuous strip of wetting along the crop rows.

Fertigation

Fertigation is the application of chemical fertilizers with irrigation water. Drip irrigation provides possibilities for precise application of fertilizers and other chemicals. The high efficiency of water application reached in drip irrigation system is ideal for the high efficiency of applied nutrients in fertigation (Bressler, 1997). This improved use efficiency of fertilizer (Bar-yosef et al 1991), reducing nutrient losses due to leaching (Bressler, 1997), thereby limiting ground water pollution, better control of the soil solution nutrient contents (Bar-yosef *et al.*, 1991), reducing soil solution salinity due to fertilizer and eases of application, reducing labour and saving energy, are the prevailing potential advantages of fertigation. But, some of these potential benefits can reverse into disadvantages when the irrigation system design or management is not corrected (non- uniform nutrient distribution, over fertigation, excessive leaching, and closing). Therefore, it is most important for a proper fertigation to reach an adequate and efficient irrigation.

Fumigation

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 sprayed regularly checks the insect incidence. Disinfect the seed or the planting materials before they are moved into the greenhouse. Disinfectant solution such as trisodium phosphate or potassium permanganate placed at the entry of the greenhouse would help to get rid of the pathogens from the personnel enter

INTEGRATED DISEASE MANAGEMENT UNDER PROTECTED ENVIRONMENT

Integrated disease management is the practices of using of range of measure to prevent and manage diseases in crop. Hazard analysis is used to identify the potential for infection so that preventive or curative measure can be put in place to minimize the risk of disease infection and spread. During the cropping cycle, regular crop monitoring is used to decide an action is needed.

Component IPM/IDM

IPM/IDM is a total technology approach involving the flowing components:

- Host plant resistance –variety selection
- Cultural practices: crop rotation, side selection, sanitation and tillage, time of planting, fertility and water management, time of harvesting etc.
- Monitoring and sampling technique
- Biological control

- Bio pesticides
- Expert system- forecasting of disease and insect pest
- Chemical control
- Regulatory programmes (plant quarantine, certification of plant material etc.)

Control access to the greenhouse

It is important to understand those pathogens are easily carried on clothing and shoes. Many diseases in green houses in greenhouse crops first appear near doorway. The fewer people entering the greenhouse, the smaller the change the pathogen will be carried in to the crop.

When people are visiting, have them wear disposable overalls. Avoid having visitors who have come directly from another greenhouse, reduce the risk of spreading pathogens.

- Use of disease free plants
- Control of growing environment
- Maintain of proper humidity
- Maintain of irrigation
- Regular inspection of plants
- Proper water management
- Control of insects and weeds
- Uses of fungicides

Integrated disease management strategies

1. Seed borne diseases: the use of certified seed is recommended, although this is no absolute guarantee that such seed are disease free. However, the use of certified seed is very common.

2. Soil borne diseases: Soil fumigation with methyl bromide to control soil fungi and root knot is considered as one of the main factor for the successful cultivation of ornamentals. Many other chemical *viz*; Dazomet, Aldicarb, Dichloropropene.

Soil solarization is promising technique. Soil solarization technique is relatively cheap, and effective. Old plastic tunnel covers for soil solarization is effective and control many pathogens such as *Fusarium*, *Verticillium* and *Meloidogyne*.

3. Air borne disease: prevention of air borne disease is not very successful in those greenhouses which are not adequately ventilated. Sanitation and hygiene may help to limit disease development in greenhouse. Fungicide application currently is the dominant management method applied in controlling air borne disease in greenhouses.

INSECT-PEST MANAGEMENT PRACTICES UNDER PROTECTED CULTIVATION

Ornamentals are more prone to insect-pest as compared to other particularly under protected cultivation due to congenial environment condition.

Insect-pest problem in protected cultivation

- Frequent in/out movement of plants helps in introduction of pest
- Year round growing inside greenhouse make conditions more favorable for pest development

MEDIA FOR PROTECTED CULTIVATION OF ORNAMENTALS

- A desirable medium should have a good balance between physical properties like water holding capacity and porosity.
- The medium should have good nutrient-holding capacity
- The medium should be free from weed seeds, insect pest nematodes and various other pathogens.
- It should provide adequate nutrient to the plants Medium which is too compact creates problems of drainage and aeration which will lead to poor root growth and may harbor 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, however some crops require a specific (EC) of the medium for proper growth *Petunia*, *Snapdragon* and *Nicotiana* grow well in a media having CE of 1.0 to 2.5ds/m.
- The most common soil less medium used for greenhouse production of ornamentals are peat, sphagnum moss, vermiculite, cocopeat, perlite and leaf mould

STANDARDIZATION OF AGRO-TECHNIQUES FOR CULTIVATION OF ORNAMENTALS UNDER COST EFFECTIVE GREENHOUSE

Greenhouse cultivation in India is of recent origin and is being increasingly practiced for

Production of quality produces in the off-season for export. Ornamental plant production and export oriented floriculture units can be successful only if the production is high and quality is excellent. In order to ensure consistency in the quantity and quality of production at reasonable cost, it is necessary to adopt latest technologies of greenhouse production.

Studies on the standardization of agro-techniques and utilization of cost-effective greenhouses for commercial cultivation of roses, gerberas, carnation and tuberose for getting higher productivity of quality flowers and high returns are summerized below.

1. Roses cultivation under naturally ventilated greenhouse

Planting of rose plants at a density of 7 plants/m² (45cm between the row and 15 cm between the plant in double row system) with recommended dose of fertilizers through fertigation along with foliar application of micronutrients (multiplex 2 ml/l of water) at weekly interval is recommended to get maximum flower yield 196 fl/m²/year and 20,000 flowers/100m²/year realizing a net profit of Rs.10,000/100m²/year).

2. Gerbera under naturally ventilated greenhouse

Planting of gerbera plants at a spacing of 30cm x 30 cm with 80 per cent of the recommended dose (12:8:25 g NPK/m²/week) of fertilizers through fertigation along with foliar application of micronutrients (multiplex 2 ml/l of water) at weekly interval is recommended to get maximum flower yield of 21,600 flowers/100m²/year realizing a net profit of Rs. 47,000/100m²/year) from gerbera under naturally ventilated greenhouse

3. Carnation under naturally ventilated greenhouse

Planting of carnation plants at a density of 25 plants/m² with 80 per cent of the recommended dose (15:8:30 g NPK/m²/month) of fertilizers through fertigation along with use of Azotobactor (250 g/ha.) at weekly interval is recommended to get maximum flower yield of 31,300 flowers/100m²/year realizing a net profit of Rs. 30,000/100m²/year) from carnations under naturally ventilated greenhouse.

4. Tuberose under naturally ventilated greenhouse

Planting of tuberose bulbs at a density of 34 bulbs/m² with 250 per cent of the recommended dose (40:40:40 g NPK/m²/year) of fertilizers through fertigation at weekly interval is recommended to get maximum flower yield of 14,300 flowers/100m²/year realizing a net profit of Rs. 32,000/100m²/year) from carnations under naturally ventilated greenhouse.

5. Limonium under shade net and under green house.

Application of 50% N + 50% P +100% K+ Vermicompost (8.3t/ha.) +Azotobactor (200g/ha.)+ Bacillus megatherium var. Phophtic (200 g/ha.) will not only produce maximum number of spikes (90.06 /m²/year) of excellent quality (133.66 cm length and 108.16 cm spike spread) but also realizing highest returns.

CONSTRAINTS OF PROTECTED CULTIVATION

- Agro-climatic constraints
- Lack of high yielding varieties
- Hurdles in transfer of technology
- People's lack of interest
- Lack of technical know how
- Lack of adequate power supply
- Lack of quality planting materials
- Insufficient technical manpower
- Lack of post-harvest technology
- Excessive dependence on outside world
- Lack of location specific polyhouse designs.
- Non availability of quality polyethylene sheet.

FUTURE STRATEGIES

- Encouragement of environmentally degradable material in floriculture.
- Development of need based polyhouse designs for different areas.
- Ensuring easy availability of U.V. stabilized plastic sheet and nets.
- Development of suitable varieties specifically for polyhouse cultivation.
- Work on eco-friendly nutrient and pest management to be taken up.
- Use of new hi-tech techniques under protected condition.

CONCLUSION

The protected cultivation of high value crops has become irreplaceable both from economic and environmental points of view. It offers several advantages to grow high value crops with improved quality even under unfavourable and marginal environments.

The protected cultivation technology is still in its preliminary stage in India and concerted efforts are required from all concerned agencies to bring it at par with

the global standards. Globalization coupled with economic liberalization will help in achieving the desired results. Greenhouse technology has got a tremendous role in keeping up the pace of precision farming in Indian agriculture. Protected cultivation not only increases the sustainability of agricultural production but also improves the standard of living.

Necessary steps to maintain the glory of the greenhouse Industry include:

- Improving the domestic markets facilities to offer high prices for the products of greenhouse.
- Exploring high value product alternatives such as propagating materials of export oriented crops.
- Developing vertical integration and joint ventures that could be adopted by Indian growers.
- Establishing a network of support systems from the government, universities and the private sector will be of immense value for growers and the industry.

In ornamentals it is essential to develop appropriate cost effective greenhouse technology and organize special training programmes and demonstrations for enhancing the protected cultivation of ornamentals.

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