BEST GROWTH OF FRUIT CROP UNDER PROTECTED CULTIVATION IN INDIA

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ABSTRACT: Protected cultivation may also indicate comprehensive system of controlled environmental agriculture in which all aspects of the natural environment are modified for maximum plant growth and economic return. Protected cultivation though has variety of agriculture application(poultry, mushroom, orchids etc) but mainly it is being considered for the production of horticulture crops like vegetables andornamental foliage and flowers. Urban areas are well suited for protected cultivation of fresh fruits, flowers and vegetables. Urban horticulture canbe in the form of home gardens, terrace garden, container gardens, plant nurseries, multistory greenhouses etc. with advancement oftechnology it has been possible to grow plants without soil with alternate substrates like coco peat, sphagnum moss, coir dust, bio char,coir peat, perlite, vermiculite, sand, gravel, wood fiber, Rockwool, sheep wool, brick shards etc not only horizontally but vertically also.Protected cultivation of vegetables like tomato, capsicum and parthenocarpic cucumbers under different protected structures particularlyin naturally open ventilated polyhouse has been proved more remunerative than open field cultivation. So is the case with theproduction of cut flowers like rose, lilium, chrysanthemum, carnation and anthurium. Production of strawberry under plastic mulch andhydroponically has been a rewarding experiment with its adoption by progressive growers throughout the country. Another milestoneunder protected cultivation of off and on season multiplication/raising seedling plugs in soilless media of different horticultural cropshas been acknowledged by Indian nurserymen for mass multiplication.This issue covers articles detailing assistance by National Horticulture Board for protected cultivation, rain shelter vegetable cultivationbesides news on global development on protected cultivation. Efforts have been made to cover topics of interest on protected cultivationfor the benefit of all stakeholders.

***Keyword**:* Protected cultivation, greenhouse, nethouse, polytunnel, NHM and horticultural crops.

Protected cultivation, which enables some control of wind velocity, moisture, temperature, mineral nutrients, light intensity, and atmospheric composition, has contributed and will continue to contribute much to a better understanding of growth factor requirements and inputs for improving crop productivity in open fields. Protected cultivation is a unique and specialized form of agriculture. Devices or technologies for protection (windbreaks, irrigation and soil mulches) or structures (greenhouses, tunnels and row covers) may be used with or without heat. The intent is to grow crops where otherwise they could not survive by modifying the natural environment to prolong the harvest period, often with earlier maturity, to increase yields, improve quality, enhance the stability of production, and make commodities available when there is no outdoor production. The primary emphasis is on producing high-value horticultural crops (vegetables, fruit, flowers, woody ornamental, and bedding plants). Production areas, structures, and crops have been expanding rapidly during the past century (Sidebar). From the beginning agricultural production has been primarily outdoors. It is a major industry that is primarily climate and weather dependent. In fact the most determinate factor in horticultural crop production is the climate.Protected cultivation is the modification of the natural environment to achieve optimum plant growth. Modification can be made to both the aerial and root environment to increase crops yields, extends the growing season and permit growth during periods of the year not commonly used to grow field crops (Layne*et al.*, 2012). Protected cultivation may also indicate comprehensive system of controlled environmental agriculture in which all aspects of the natural environment are modified for maximum plant growth and economic return. Protected cultivation though has variety of agriculture application(poultry, mushroom, orchids etc) but mainly it is being considered for the production of horticulture crops like vegetables andornamental foliage and flowers. Rapid urbanization, an indicator of progress and prosperity, is a favorable factor for development ofprotected cultivation. Urban areas are well suited for protected cultivation of fresh fruits, flowers and vegetables. Urban horticulture canbe in the form of home gardens, terrace garden, container gardens, plant nurseries, multistorey greenhouses etc. With advancement oftechnology it has been possible to grow plants without soil with alternate substrates like coco peat, sphagnum moss, coir dust, bio char,coir peat, perlite, vermiculite, sand, gravel, wood fiber, rockwool, sheep wool, brick shards etc not only horizontally but vertically also.The substrates are fertigated frequently or as per requirement of crops. The system is called hydroponics which is an age old practicebut uncommon in India. Same hydroponic system can

be used without using substrate where roots of plants are periodically sprayedwith nutrient solutions (aeroponics). Such soilless farming can be done at any space available in the houses/flats and multi- storeygreenhouses. This issue of magazine covers article on such farming besides cultivation under naturally ventilated polyhouses, net andshade houses, rain shelters, low plastic tunnels/covers, plastic mulch, micro irrigation etc.

Protected cultivation of vegetables like tomato, capsicum and parthenocarpic cucumbers under different protected structures particularlyin naturally open ventilated polyhouse has been proved more remunerative than open field cultivation. So is the case with theproduction of cut flowers like rose, lilium, chrysanthemum, carnation and anthurium. Production of strawberry under plastic mulch andhydroponically has been a rewarding experiment with its adoption by progressive growers throughout the country. Another milestoneunder protected cultivation of off and on season multiplication/raising seedling plugs in soilless media of different horticultural cropshas been acknowledged by Indian nurserymen for mass multiplication.This issue covers articles detailing assistance by National Horticulture Board for protected cultivation, rain shelter vegetable cultivationbesides news on global development on protected cultivation. Efforts have been made to cover topics of interest on protected cultivationfor the benefit of all stakeholders.

PROTECTIVE CULTIVATION METHODS/STRUCTURES

The kinds of protective structures for crop production range from simple provisions such as rain shelters, shade houses, mulches, row covers, low tunnels, clothes to greenhouse structures with passive or active climate control. Although other fruits are grown using this technique including strawberry, grape, cherry, apricot, and plum (Gao *et al.,* 2004), recent estimates for the peach and nectarine segment of the protected cultivation industry suggest that approximately 80% is nectarine while 20% is peach (Wang and Niu, 2012). There are two basic types of protected cultivation greenhouses for commercial fruit production in China. The first is the single-slope, energy-efficient, solar-heated, lean-to greenhouse. These simple, inexpensive houses occur primarily in northern China (32 – 47°N latitude) where the winters are cold but sunny (Gao *et al.,* 2010, Jiang *et al.,* 2004 and Jiang and Yu, 2008). They are oriented East-West and they face South for maximum sunlight absorption during the winter. Essentially, they are half Quonsets where the back (North) and sidewalls absorb heat, provide support and protect against cold outside winds (Jiang and Yu, 2008). On top of the north wall, there is a short roof. The roof is composed of water resistant materials that are load bearing and that preserve heat. With an angle

of elevation of 35-40 degrees for the back roof, winter sunlight can reach the back wall (Jiang *et al.,* 2004). Often, these individual lean-to houses are 300 – 800 m^2 in area. Typically, they are 40-100 m long, 6-8 m wide and 3-4 m tall with a back wall that is 0.5-3.0 m thick depending on the material it is made from (Jiang and Yu, 2008). Back and sidewalls may be soil, brick, cinder block or stone. In some cases, the walls may be constructed with two brick layers with perlite, coal cinders or other insulating material in between to reduce heat loss (Jiang *et al.,* 2004). One farmer and his family typically have 1-2 greenhouses to manage for themselves.4

Greenhouse structure and designs: A greenhouse is a framed or 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 a person to work within it to carry out cultural operations. Greenhouse are framed or inflated structures covered with plastic material or glass in which crops can be grown under partially controlled environment which is large enough to permit normal culture operation manually. Greenhouse technology was well adapted in Europe and USA by the end of the nineteenth century. Presently, China and Japan are the leading countries. Greenhouses are suitable for growing a variety of fruits and throughout year cultivation even under extreme climatic conditions is possible through greenhouse. Seedlings and cutting preparation is also reduced significantly with the application of greenhouse technology. Grafted trees with the desired scion cultivar on wild peach seedling rootstock are typically planted high density (1 m x 1.5 m, or 1.2 m x 1.5 m, or 1.5 m x 2 m). They are usually trained to a central leader where laterals may be horizontally positioned by strings for better sunlight exposure and improved fruit coloration and quality (Zhu, 1999). They may or may not be on a raised bed depending on the preference of the grower. Irrigation is most common by flooding but some growers use a drip system. Both production systems are typically productive for 10 or more years. The greenhouse may be intercropped with another fruit such as strawberry during the first or second year.

Type of green house: The greenhouses design and cost range from a simple plastic walk in tunnel costing about Rs.100/- per sq. meter to a climate controlled, saw-tooth greenhouse with automatic heating, ventilation and cooling, costing more than Rs. 3000/- per sq. meter. The selection of the greenhouse design should be determined by the grower's expectations, need, experience, and above all its cost effectiveness in relation to the available market for the produce. Obviously, cost of greenhouse is very important and may outweigh all other

considerations. Greenhouses are classified in different shapes, which also determine their cost, climate control and use in terms of crop production.

Gable: This is the most basic structure similar to a hut like construction and was perhaps the first version of a greenhouse with glass as the covering material. The roof frame can be inclined at any angle to present an almost perpendicular face to the sun to minimize losses due to external reflection. The structure also allows large openings in the side walls and at the ridge for high rates of natural ventilation. Modern gable shaped greenhouses are multi-span units with bay widths of 6-12 meters.

Gambrel: These structures are similar to the gable but have high strength to withstand high wind loads during storms. This design is more suitable where wood or bamboos are to be used for the greenhouse construction.

Skillion: In this kind of structure, the roof consists of a single sloping surface. This is because the greenhouse is built as the southward extension of a building with a solid wall on the northern side. Such greenhouses have the advantage of low structural requirements.5

Curved-roof: The semi-circular tunnel greenhouse structures appeared with the introduction of polyethylene film as the covering material. These structures, besides being most simple and easy to construct, have the advantage of high strength with a relatively light frame due to inherent strength of the curved arch. But these structures have the disadvantage of poor ventilation efficiency since the curved roof is not amenable to the incorporation of ridge ventilators. In an attempt to improve the ventilation efficiency of curved roof greenhouses, raised arch type of structures have been adopted. This design has vertical sidewalls, which permit high head room and improved ventilation due to the wind velocity.

ROLE OF PROTECTED CULTIVATION IN FRUIT CROPS

1. Uniform and better quality production and fresh fruits availability
2. High productivity
3. Weed free cultivation
4. Efficient use of resources
5. Regulate harvesting time to reduced post harvest losses
6. Round the year as well as off -season cultivation is possible in hostile climates
7. Better insect past and diseases control with lesser use of pesticides
8. Employment generation from small holding

9. Create micro-climate for optimum plant performance
10. Check the loser from natural calamities
11. Conservation of biodiversity
12. Breeding for resistance to abiotic stresses

ROLE OF PROTECTED CULTIVATION ON FIELD ENVIRONMENT

In mango: Medany *et al.,* 2009, conducted study on suitability of white greenhouse net cover for growth of mango (*Mangifera indica*. L.) cv. Keitt cultivar they found that, maximum temperatures tended to be lower under the nets (2^0C), due to the interception of radiation which is greater than the gain of temperature caused by the use of nets due to their role in the interception of air circulation or "greenhouse effect". Bigger differences were recorded on the growing seasons. Minimum temperatures tended to be lower in the control by 1^0C than in the nets because of the greenhouse effect and the low radiation at this time of the day. Average relative humidity increased by the use of white net by 4-8% compared with open field, the increase in humidity associated with the use of nets. These authors also reported a decrease in evaporation associated with the use of nets and a significant reduction in wind speed.

In banana: In summer the green houses were cool in greenhouses it was reduced the by 8^0C compared with under canopy temperature levels outside the greenhouse. Before turning the overhead cooling system, the humidity was already up to15 per cent higher inside the greenhouse than outside. After turning over head cooling system the humidity was increase up to 18% per cent.

In grape: Jaing *et al.,* 2009, the impermeable plastic covering above the grapevines rows increased the air temperature and decreased the photosynthetic radiation and wind speed. The covering interfered with the quality of the incoming solar radiation, mainly by reducing the irradiance in the ultraviolet band and also by reducing the ratio between the irradiance in the red and far-red bands.

PROTECTED CULTIVATION TECHNOLOGIES

The several technologies like high tunnels, mulching, bagging, drip fertigation, net house, raise bed and Earth Tube Heat Exchanger (ETHE) for the hot humid areas are help to successfully fruit production and plant multiplication.

- Drip fertigation

- Raised beds
- Mulching with different colour of plastic
- Tunnels plastic covered and insect screen covered
- Net-house, Shade nets (Intensity and colour) and insect-proof nets (Porosity) Protection against animals, birds excessive radiation, wind and hails
- Greenhouse, mist chambers etc.

High tunnels: Also known as walkin tunnels, high tunnels are protective structures tall enough that the crop can be manipulated from within. Moderately tall crops can be cultivated in high tunnels, although planting near sidewalks is limited. Statistics for high tunnels are often included in the same category as low-cost plastic greenhouses, because the cladding or covers are similar. Cladding materials are practically the same as those used in low tunnels (Coneva, 2010).7

Low tunnels: Low tunnels are small structures that provide temporary crop protection. They are also known as row covers. Their height is generally 1m or less, with noises for walking. Cultural practices must be performed from the outside. Their use enhances early and total yields and they offer protections against unfavorable climatic variables. A thermal film of infrared PE, EVA, copolymer, polyvinylchloride (PVC) and conventional PE is being used worldwide.

Plastic tunnels: These are miniature structures producing greenhouselike effect. Facilitates the entrapment of carbon-dioxide thereby enhancing the photosynthetic activity. Itprotects plants from harsh climatic conditions such asrain, wind and hail snow etc. These are mainly used forraising nursery.

Advantages

1. Protects from hostile climate.
2. Helps in early seed germination.
3. Round the year cultivation is possible.
4. Healthy saplings can be raised.7

Mulching: Mulching is done to cover the soil around plants with a protective material, which may be organic or synthetic. Organic mulches, like leaves, saw-dust etc. Add nutrients and humus to the soil as they decompose, improving its tilth and moisture holding capacity. Synthetic or plastic mulches have various beneficial effects on crop production. Transparent polyethylene mulch raises the soil temperature. This effect derives mostly from the suppression of latent heat loss through evaporation. The mean difference in soil temperature between transparent film

mulched and bare soil in early February in Delhi was observed to be 5^0C in the top 7cm of soil where most of the root zone of young musk-melon existed. It increased the plant growth by about 15% during the same period.Mulching conserves the soil moisture and fertility. The former is higher with black plastic than under the transparent plastic. Mulching prevents the leaching of fertilizer, because it acts as a physical barrier to rainfall, thereby conserving the fertility. Black polyethylene film also gives effective weed control by cutting down solar radiation by more than 90%, resulting in etiolated growth and the eventual death of weeds under the film (Amani and Avagyan, 2014). Transparent film, on the other hand, has little effect on weed control unless the film is coated with weedicides. Plastic mulch is also effective in the control of pests and diseases. Silver coloured film is used as mulch to suppress the increase in soil temperature and to control pests and diseases. The silver colour acts as a repellent to aphids, which transmit viruses. On the other hand, yellow colored mulches attract insects, which could be killed easily. Muskmelons, tomatoes, peppers, cucumbers, squash, eggplant, watermelons and okra are vegetable crops that have shown significant increases in earliness, yield, and fruit quality when grown on plastic mulch.8

PLASTIC MULCHING FOR FRUIT CROPS

In-situ moisture conservation: Plastic mulching is covering the soil around the plant with plastic film to conserve the soil moisture that prevents weed growth and regulate soil temperature.Polyethylene bunch cover on deferent fungal diseases control of fruit crops specially banana fruits (Amani and Avagyan, 2014). Presently there different colour plastic films used as mulches such as black, silver-black, red, yellow, while black etc.

Advantages

1. Prevents weed growth and acts as barrier to soil pathogens.
2. Accelerates uptake of micro nutrients from the soil by the active root zone.
3. Conserves soil moisture thereby reduces the irrigation water requirement of the crop.
4. Enhances quality of the produce with cleaner crop.8

Bagging/bunch covering: Bagging of fruit at pre-harvest is also being used to protect the plant form insect infestation, improved quality in terms of appearances and size of fruits and the increased the yield in various fruits crops.

Net-house: Shade house and net house are often synonymously used but more correctly a net house is enclosed with perforated screen primarily to act as a barrier for the entry of insects and

pests. Insect proof nylon nets are available in different intensities of perforations, ranging from 25 mesh to 60 mesh. Nets of 40 mesh or higher mesh are effective means to control entry of most flying insects and save crop from diseases. These structures permit early planting of tomatoes and capsicum without the risk of vector. Higher mesh size, however, reduces the air exchange of the structure. UV stabilized nets are now available which have a longer life.

A simple bamboo framed greenhouse suitable for North-East region where bamboo grows in plenty. Preference for local materials should be given if the construction is cost effective in long run. A simple wooden framed, saw-tooth design of naturally ventilated greenhouse for raising nursery. Walk in tunnel and raised-arch type of greenhouses are easy to build in low cost. The walk in tunnel has poor ventilation and thus of limited annual use with plastic cover. Its annual use can be enhanced by replacing the plastic cover with insect proof net during hot season. The raised arch structures have better ventilation and can be used almost year around for crop production. The orientation of both the structures should be North-South lengthwise. Avoid fruit cracking. Fruit cracking is the result of morphological, physiological, environmental and genetic factors. Several advances in the use of different culture practices, which reduce fruit cracking have however been made. These practices include exclusion of water from the fruit using plastic rain covers and reducing osmotic potential across the fruit skins during rainfall events using calcium products.

PROTECTED CULTIVATION ADVANTAGE

i) Higher yield

ii) Better quality

iii) Off-season production

iv) Assured and early production

v) Least pesticide residues

vi) Controlled pollination

vii) Vagaries of weather

viii) Easier plant protection

ix) Weed free cultivation

x) Protected Cultivation Constrains

xi) Basic cost and operational cost very high

xii) Irregular power supply

xiii) Little work on designing in different locations

xiv) Cladding material quality/availability

xv) Lack of technical knowhow10

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