

Protected Cultivation of Horticultural Crops



Precision Farming Development Centre
ICAR-Central Institute for Subtropical Horticulture
Rehmankhara, P.O. Kakori, Lucknow-226 101 (U.P.)

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Edited by
V.K. Singh, S. Rajan
Anurag Singh and Manoj K Soni



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Foreword

India is currently producing about 283 million tones of horticulture produce and has surpassed the food grain production in the country. It has proven beyond doubt that productivity of horticulture crops is much higher compared to productivity of food grains. Productivity of horticulture crops has increased by about 34% between 2004- 05 and 2014- 15. India is the second largest producer of fruits and vegetables globally. Horticulture contributes about 30% of GDP in agriculture, using only 17% land area. Area under horticulture increased 29% in 8 years, from 18.7 million ha in 2005- 06 to 24.2 million ha. in 2013-14 as more farmers are venturing into horticulture in their quest for diversification in agriculture. Horticulture production increased from 167 million tones in 2004- 05 to 283 million tones in 2014-15 or 69% increase in 9 years. Productivity of vegetables in India continues to be low compared to world average productivity Per capita availability of vegetables in India is 357 gm/ person/ day, which is helping in overcoming malnutrition. India is second largest producer of vegetables after china and is a leader in production of vegetables like peas and okra. Besides, it occupies the second position in production of brinjal, cabbage, cauliflower and onion and third in potato and tomato in the world.



With the advancement in agriculture, various types of protected cultivation practices suitable for a specific type of agro-climatic zone have emerged. Protected cultivation is a cropping technique wherein the micro climate surrounding the plant body is controlled partially or fully as per the requirement of the plant species grown during their period of growth. This technology has spread rapidly over the last three decades into relatively new areas all around the world. There is need to assess the presence of technologies in India, its status and acceptance amongst the growers and farmers.

Majority of the vegetable growers in the country are facing the adversities of harsh climate and promoting protected cultivation as intensive system for year round production of high value crops. Augmenting productivity can also help the farmers in mitigating the climate change.

Precision Farming Development Centre, ICAR-Central Institute for Subtropical Horticulture, Lucknow, has carried out pioneering research on the above aspects and has demonstrated the technologies. This National Workshop-cum-Seminar on "Emerging Prospects of Protected Cultivation in Horticultural Crops under Changing Climate" scheduled during December 22-23, 2015 at this Institute is an effort to understand, discuss, share experiences and disseminate the knowledge among the stakeholders who will be taken on board in order to pave way for strategy and policy alignment.

I sincerely hope that the two days event would identify future thrust areas and strategies and enlarge the knowledge base of the stakeholders and end users in order to render this technology vibrant in the country. I hope the present publication brought out on the occasion would be widely used by scientists, teachers, scholars, policy makers and orchardists. I also complement Dr. V.K. Singh, Principal Scientist, PI, PFDC and the staff team, for this fruitful endeavour.

A stylized handwritten signature in black ink, appearing to read 'Shailendra'.

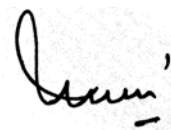
(SHAIENDRA RAJAN)
Director

Preface

Protected cultivation is the most contemporary approach for production of horticultural crops which is highly productive, efficient and judicious use of water, land and other inputs like pesticides. The challenge of increasing production can be overcome by mitigating the effects of harsh climate. Protected cultivation is also one of the technologies that can provide opportunities for assured, climate-resilient and enhanced production of quality planting material by diminishing the adverse effect of climatic condition. It has potential to provide near optimal conditions by controlling the climate using different protected structures/ methods/ devices and phenomenally increasing the productivity manifolds.

The high value crops can also be grown round the year, including off-season, fetching high market price resulting in increased profitability. In order to meet the requirement of fresh produce, multistoried vertical farms under protected conditions in the peri-urban areas are the need of the day; good agricultural practices under protected condition and integrated pest, water, nutrient, weed management, pollination, training of crops, harvesting practices, etc. are crop-specific and different than open field conditions thus require climate refinement. High value crops viz., tomato, coloured capsicums, parthenocarpic cucumber, flowers, strawberries can be successfully cultivated in the off season also. Recently, there is a large scale adoption of high density orcharding system by increasing the planting density per unit area. Therefore, there is increasing demand by the growers for high quality planting material of newer varieties suitable for high density planting. This can be only achieved by hi-tech nurseries with facilities for year-round propagation. Greenhouse technology has become an important tool in nursery business by achieving better germination under low tunnels and higher graft success rate under polyhouses/ nethouses giving assured better returns to the nurserymen. Walk-in tunnels, due to their low initial cost are also suitable and effective to raise off-season nursery of vegetable crops.

I am confident that this publication will be of immense use to the stakeholders, entrepreneurs, value chain managers, extension functionaries and the agencies associated with the production, utilization and trade of high value crops. I thankfully acknowledge Dr. S.K. Malhotra, Agriculture and Horticulture Commissioner, DAC, GOI, NCPAH, New Delhi and Director, Horticulture and Food Processing, U.P. for help in this publication. My sincere thank to all the staff of PFDC, Central Institute for Subtropical Horticulture, Lucknow for helping in bringing out this publication.



(V.K. Singh)
Principal Scientist &
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Protected Cultivation of Horticulture Crops

The impact of abiotic and biotic stresses under the present changing climate dictates the crop production and quality. The foremost constraints in horticultural crop production in North Indian condition are the extremes of temperature, sunlight, water, relative humidity, weeds, nutrient deficiency, wind velocity, carbon dioxide concentration and diseases and insect pest incidence. Protected cultivation means to grow with improved quality out of season under protected structures, thereby increasing the profitability for the farmer especially in hostile climatic conditions. This technology has a potential to cater for supply of high quality vegetables, flowers and fruits in the peri-urban areas by reducing the transportation time and delivering fresh produce.

Greenhouses are structures covered with transparent material such as polythene or glass. The covering acts like a selective radiation filter and allows short wave length solar radiation to pass but traps the long wave length radiation. The long wave radiations emitted by the plants and objects in the greenhouse cannot pass through the covering material owing to its lesser transparency for it. This results into rising of the temperature inside the greenhouse due to trapped solar energy inside the greenhouse (greenhouse effect). The increased temperature inside the greenhouse affects the leaf temperature, which in turn influences the leaf transpiration, stomatal aperture and also the photosynthetic rate of the plants. The climatic control in the green house can be used for altering the physiological conditions of the plants. Closing of the greenhouse during the night the rises the

CO₂ level resulting from respiration by the plants that in turn is used for photosynthesis by the plants during the early morning hours of the following day. The rise in temperature, relative humidity, CO₂ level and enriched nutrition under protected conditions of the greenhouse is accountable for fast growth and increased production. The temperature in greenhouse can be brought down by providing cooling through ventilation, fogging or operating the fan pad system. This facilitates round the year production of desired vegetable crops and exploits their maximum yield potential. Higher plant density by closer planting and higher number of fruiting branches per unit area under protected cultivation increases the yield tremendously.

The management practices for protected cultivation are different than for open field production. Multistoried crop cultivation in greenhouses in the peri-urban areas is the need of today in order to meet the requirement of fresh vegetables, strawberry, flowers and fruit tree nursery. Protected cultivation technologies include naturally-ventilated polyhouses, drip irrigation, fertigation, mulching etc. Recently, walk-in polytunnels becoming profitable technologies under Northern plains of India proving its suitability for cultivation of tomato, capsicum, cucurbits and raising nursery during off season.

Agriculture is not a lucrative profession for the educated youth mainly due to the hardship associated with field work. Modern technologies like protected cultivation should be a remunerative and competitive as any other industry in order to motivate them. Only then, a sense of

pride will be associated with agriculture and prevent the migration of the rural youth towards the urban areas in search for better livelihood options. Being capital intensive, high cost of finance and delays in approval of loan requests, this technology has suffered slow adoption rate. In this regard, Govt. intervention for making low cost timely institutional finance available to the farmers is being given top priority to make adoption of this venture on a large scale.

Precision Farming Development Center, ICAR-CISH, Lucknow has demonstrated the off season production of high value vegetables like tomato, cherry tomato, coloured capsicum and parthenocarpic cucumbers under polyhouse. The yield was enhanced to a substantial level by growing tall indeterminate hybrids and adopting good management practices. The temperature reduction of 5-7 °C along with RH enhancement of 35-60 % during summers and temperature increase of 3-5 °C and RH reduction up to 25-35 % RH during winter in the polyhouse was observed.

The positive influence of polyhouse on the morpho-phenological and physiological events of the high value crops viz. tomato, coloured capsicum, parthenocarpic cucumber, strawberry, melons during winter and cut flowers is depicted on the enhancement in the duration of the crop under the controlled conditions.

Factors affecting the adoption of protected cultivation

1. Climatic and soil conditions
2. Type of crop chosen
3. Resources available with the farmer
4. Govt. Sponsored schemes, if available
5. Market availability for selling the high quality produce

Advantages

- Provides favorable micro climate conditions for the plants.
- Cultivation in all seasons even under extreme conditions is possible.
- High yield with better quality per unit area.
- Longer production cycle
- Needs less irrigation due to moisture conservation.
- More suitable for off season/ high value crops.
- Hygienic production due to less sprays of toxic pesticides
- Better disease and pest control.
- Helps in early raising of nursery.
- Round the year propagation of elite planting material.
- Protection from wind, rain, snow, birds, hail etc.
- Generates self employment for educated youth.

Types of greenhouse/polyhouse

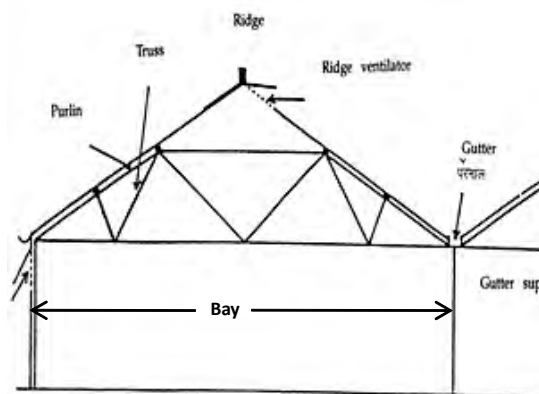
1. Low-cost greenhouse/polyhouse:

Low cost polyhouse is made of 200 micron (800 gauge) transparent polythene sheet supported on bamboos with jute sutli (ropes) and nails. It is used for protecting the crop from high rainfall. The temperature within polyhouse increases by 6-10 °C more than outside. In UV stabilized plastic film covered pipe framed polyhouse, the day temperature is higher than the outside. The solar radiation entering the polyhouse is 30-40% lower than that reaching the soil surface outside. During summers, the sides can be opened to moderate the temperature within the greenhouse in day time.

2. Medium-cost greenhouse/polyhouse:

A medium-cost greenhouse having slightly higher cost is quonset-shaped that

can be made with GI pipe (class B) of 15 mm diameter. The structure is covered with single layer of UV-stabilized polythene of 200 micron thickness. It can be naturally ventilated by providing openable windows along the sides and the roof or else exhaust fans may be used for ventilation. The fan-pad system can also be used for humidifying the polyhouse, thus lowering the temperature. The life span of frame and covering material is about 10 years and 3 years, respectively.



Components of Polyhouse

3. High cost greenhouse/polyhouse:

It is constructed with iron/aluminum structure (frame) having dome or cone shaped design. Temperature, humidity and the light are automatically controlled as per crop requirement. Floor and a part of side walls are made of concrete. It is highly durable but the cost is about 5-6 times. It requires qualified operator, proper maintenance, care and precautions during operation.

tunnels are very simple structures requiring some degree of skills to construct and offer many advantages. For construction of low tunnels, film of 100 micron is sufficient. The cost of a 100-micron thick film is about Rs.10-20 per m². These are used to cover the seedling beds or the individual growing beds in the field. When the climatic conditions are favourable the cladding material may be removed.

4. Other protective structures

b. Net houses

a. Plastic low tunnels

Plastic low tunnels are miniature form of greenhouses 0.75-1.0m height to protect the plants from rains, winds, low temperature, frost and insect pests. The low

Net houses are used for raising vegetable and flower crops. These structures have flat top design and are of 3m height. It is covered with shading net of suitable shading capacity (35-90 % shade) and colour depending on the crop requirement.

Climatic requirement of crops under protected cultivation

Crop	Temperature (°C)		Humidity (%)	Light Intensity (lux)
	Day	Night		
Tomato	22-27	15-19	50-65	50000-60000
Cucumber	24-27	18-19	60-65	50000-60000
Capsicum	21-24	18-20	50-65	50000-60000
Nursery	22-27	16-19	50-65	50000-60000
Carnation	16-20	10-12	60-65	40000-50000
Chrysanthemum				
a. Cut flower	22-24	15-16	60-65	35000-40000
b. Pot	23-26	16-19	60-65	35000-40000

PROTECTED CULTIVATION OF HORTICULTURE CROPS

Crop	Temperature (°C)		Humidity (%)	Light Intensity (lux)
	Day	Night		
Gerbera	20-24	18-21	60-65	40000-50000
Orchid	22-24	18-20	70-80	25000-30000
Anthurium	22-25	18-20	70-80	25000-30000
Rose	24-28	18-20	65-70	60000-70000

Source: Internet Searchable

The low and medium-cost greenhouses have ample scope in production of high value vegetables and flowers during rainy season in Northern India (July-October). Growing of vegetables such as Tomato, cherry tomato, coloured capsicum, cucumbers and pole type french beans in open conditions during this period is very difficult and low availability of these crops fetch high price in the market increasing the profitability. Severe attack of pest and diseases occur due to heavy rains. So, careful management of diseases and pests in polyhouse must be exercised.

Crops grown under protected cultivation

High value vegetables like tomato, cherry tomato, coloured capsicum, parthenocarpic cucumbers, french beans (pole type), winter watermelon, muskmelon and strawberries can be grown successfully out of season under polyhouses/ walk-in tunnels in Northern India. The technology has also been proved valuable to produce grafted fruit plants year-round.

Crop Cycle

Crops	Periods/ Crop Cycle	
	Transplanting	Harvesting
Tomato	August-September April- May February	April- May July- August May- June
Cucumber/ Cauliflower/ Leafy vegetables/ Okra	November- December April- May	March - April October- November

Crops	Periods/ Crop Cycle	
	Transplanting	Harvesting
Propagation of planting material of fruit crops	Round the year	
Muskmelon/ Watermelon	February- March	June
Flowers	Round the year	

TOMATO

Varieties

Hybrid varieties with indeterminate growth habit are suitable for greenhouse cultivation. The hybrids growing to a height of 3m and utilizing the vertical space in the greenhouse and having a yield potential of 170 t/ha and more from a crop of six month duration are best suitable for greenhouse cultivation.

- Naveen (Indo American)
- Sartaj (Beejo Sheetal)
- Avinash II (Syngenta)
- Himsona (Syngenta)
- Himshikhar (Syngenta)
- GS 600 (Golden Seed Company)
- Shreshtha (Syngenta)
- Tolstoi (CEU)

Cherry Tomato

- BR 124 (Holland)
- Pusa Cherry Type (IARI, Pusa)
- Olle
- Seran
- Regy

Nursery raising

Seedling of tomato are raised in 98 cell pro trays having drainage holes at the bottom. The growing media includes vermicompost + sand + sterilized cocopeat (1:1:1). Shallow depressions of 5 mm depth are made in each cell and seed treated with Captan (@ 0.2g /100 seed) are sown one per cell. The emerging seedlings are drenched with Copper-oxychloride solution (@ 3 g/lit), covered with a plastic sheet immediately after germination. The seedlings are provided nutrition by drenching them with 0.2 per cent, 19:19:19 (N:P:K) plus trace elements at 15 days after germination. To prevent thrips infestation, the seedlings are sprayed using Acephate (0.75g/lit). The seedlings are hardened by gradually reducing the frequency of irrigation and exposing them to sunlight. The seedling are sprayed with Imidacloprid (0.03 ml/lit) solution one day before transplanting. Drenching the seedlings with Carbendazim (0.1%) solution on the day of planting is required for avoiding damping off and better establishment. The seedlings are ready for planting within 21 days of sowing when they attain a height of 25 cm. To plant tomato in 1000 m² of greenhouse area 20 g seed is required.

Bed preparation

Soil clods are broken & soil is brought to fine tilth by digging. Beds of 100 cm width and 15 cm height are prepared leaving 50 cm footpath between the beds. In heavy soils mixing sand or decomposed rice husk up to 25% of volume is required to provide proper aeration in the root zone.

Disinfection of growing beds helps in killing of weeds, harmful organisms, fungal spores, bacteria and nematodes. During the process the temperature rises up to 60-70 °C. In June – July the beds drenched using

4 per cent formaldehyde (@ 4 liters/sqm) and the beds are covered with polyethylene (400 gauge) sheet. All the doors and ventilators are closed. After four days of formaldehyde treatment, the polyethylene cover is removed and the ventilators and the doors are opened. The beds are hoed repeatedly everyday to remove the trapped formaldehyde fumes completely before transplanting.

Fertilizer application

Well decomposed organic manure at the rate of 10-15 kg per square meter of the bed is added and mixed thoroughly before fumigation. Commercial fertilizers containing 19:19:19, N:P₂O₅:K₂O are applied @ 7 g per sqm to the growing beds after fumigation. Two furrows 10 cm deep are made adjacent to the planting rows in the growing bed, the fertilizer mixture is applied and the furrows are closed.

Laying of drip line

One inline drip lateral with 40 cm inter-emitter distance, having a discharge of 2 LPH is placed at each planting row on the bed prior to planting. The distance of the drip lines is adjusted according to the planting distance. The emitters in the adjacent rows in a bed should be adjusted so that they are not in front of each other (in triangular fashion). Before planting, the drip system is run to check uniform discharge of water from the emitters.

Mulching

Black / silver polyethylene mulch film 100 micron (400 gauge) thickness having 1.2 m width is used to cover the planting beds and securing the edges of the sheet by burying in the soil. 5 cm diameter holes are made on the mulch film using a sharp pipe at recommended crop spacing.

Spacing

Tall growing tomato seedlings are planted in two rows per bed with spacing of 60 cm x 45 cm. in a triangular fashion.

Transplanting

For better establishment of seedlings, irrigating the beds to field capacity is required before transplanting. 20-25 days old, vigorous & uniform in size 25-30 cm in height seedlings are selected for planting. The seedlings are removed from the trays by applying slight pressure on the bottom of the individual cells. Seedlings are planted in the centre of the holes made in the polythene mulch film so that the seedlings do not touch the mulch film. Beds are irrigated daily with a rose-can till the seedling establishment. If the humidity is low, the foggers are run to increase the RH level. The beds are drenched with copper oxy chloride (@ 3 g/lit) if seedling mortality due to damping off is observed.

Irrigation

Drip irrigation is started 10 days after transplanting. Drip irrigation is provided daily to supply 2 to 3 liters of water /m² / day depending on crop requirement and weather conditions.

Fertigation

The water soluble fertilizer (WSF) is given through fertigation as per following dosage.

Crop stage	NPK (formulation)	Dose (g per 500 sq. m.)
Planting to first flowering	19:19:19	250
First flowering to fruit set	19:19:19 46:0:0 0:0:50	100 175 275

Crop stage	NPK (formulation)	Dose (g per 500 sq. m.)
Fruit set to harvesting peak	19:19:19 46:0:0 0:0:50	100 250 275
Topping until crop end	19:19:19 46:0:0 0:0:50	50 125 150

The plants are fertigated twice a week, starting from 25 days after transplanting.

The crop is sprayed with micro nutrient mix solution containing ferrous, zinc, copper, manganese, boron and molybdenum (3g/l) two to three times at 30 days interval starting from 60 days after transplanting. If the crop is found to show symptoms of calcium deficiency, then the crop is fertigated twice with calcium nitrate at 15 days interval.

Pruning

Initially tomato plants spaced at 60 x 45 cm are pruned to retain two stem per plant. Pruning operation starts 20 to 30 days after transplanting at weekly interval. The main stem of tomato plants branches into two after the first flower cluster. Suckers form in the axils between the leaves and the main stem are removed. A strong main stem is encouraged by removing all suckers below the first flower cluster. Only two branches are retained & all other branches and buds/ suckers developing at the base of the stem are also removed. For pruning the entire sucker is removed at the base or the tip of the sucker is pinched out.

Training

Each branch is trained along a separate plastic twine hanging from an overhead GI wire trellis support system 3m above the ground level, so that the branches do not

break due to weight of the foliage & fruits. Tying and supporting of the branches start from one month after transplanting before appearance of tendrils at regular interval. The plants are tied carefully and tenderly in order to avoid damage or breakage to the growing parts.

Lowering of plants

The indeterminate plants tend to grow upward and they need to be lowered periodically in order to maintain them at required workable height. This is done by providing extra length of supporting plastic twine from the beginning stage. Lowering the plants is done at 20 to 30 days interval starting from 80 to 90 days after transplanting.

Deleafing

The older leaves that are shaded by the new growth or touching the ground surface are removed periodically in order to reduce the fungal infections and pest accumulation. Starting from 70 days after transplanting, leaves are retained to a length of about 1.5 m on the stem from the growing tip at any stage of growth.

Harvesting and Yield

Tomatoes are harvested at colour break stage. Harvesting of tomato starts at 70 to 80 days after transplanting & continues upto 170 to 180 days. Tomato fruit yield under polyhouse condition may reach 170 to 180 t/ ha (17 to 18 kg/ sqm or 5.7 to 6.0 kg/ plant). Individual fruit weight varies from 100 g/ fruit during initial harvests to 60 g/ fruit during last harvest.

In contrast, the yield under open field condition of 53 t/ ha (5.3 kg/sqm or 1.4 kg/ plant) only can be achieved under favourable climatic condition.

COLOURED CAPSICUM

It is also known as Sweet Pepper / Bell Pepper. Botanically it is called *Capsicum annum*. It is a cool season crop. Based on the growth habit, the plants are of two types determinate and indeterminate. It contains high amount of antioxidant i.e. ascorbic acid (140mg / 100 gm. edible portion).

Varieties

Following coloured capsicum hybrids are recommended for cultivation in North India.

Yellow fruited: Orobelle, Super Gold, NS (285 and 280), 3020, Yellow Wonder

Red fruited: Bomby, 3019, Tanvi+, Torkel

Green coloured: California wonder, Bharat, Indra, Pusa Deepti, Green Gold

Nursery raising

Seedling are raised in 98 cell pro trays having drainage holes at the bottom. The growing media includes vermi-compost + sand + sterilized cocopeat (1:1:1). Seeds are planted single in each cell. The emerging seedlings are drenched with Copper-oxychloride solution @ 3 g/lit. The seedlings are provided nutrition by drenching them with 0.2 per cent, 19:19:19 (N:P:K) plus trace elements at 15 days after germination. To prevent insect infestation, the seedlings are sprayed using Acephate (0.75g/lit) or Imidacloprid (0.03 ml/lit). Drenching the seedlings with Carbendazim (0.1%) solution on the day of planting is required for avoiding damping off and better establishment. The seedlings are hardened by gradually reducing the frequency of irrigation and exposing them to sunlight. The seedlings are ready for planting within 35-40 days of sowing when they attain a height of 20 cm with 5-6 leaves.

Bed preparation

Leveling of beds is important. Bed to bed distance should be 1.5 meters. Width of the bed is 100 cm leaving 50 cm path in between. Height of the bed should be 20 cm. Row to row spacing on bed is kept 30 cm with plant to plant distance 40 cm.

Solarization of growing beds

Disinfection of beds is done after soil preparation and application of vermicompost. Soil is wetted thoroughly with formalin 4 % solution @ 4 lit. per sqm. The surface is covered with white and transparent polythene sheet (100 micron thickness). During process the temp. rises upto 60-70 °C. This process helps in killing weeds, harmful organisms, fungal spores, bacteria and nematodes.

Fertilizer application

Well decomposed organic manure at the rate of 10-15 kg per square meter of the bed is added and mixed thoroughly before fumigation. Commercial fertilizers containing 19:19:19, N:P₂O₅:K₂O are applied @ 7 g per sqm to the growing beds after fumigation. Two furrows 10 cm deep are made adjacent to the planting rows in the growing bed, the fertilizer mixture is applied and the furrows are closed.

Laying of drip line

One inline drip lateral with 30 cm inter-emitter distance having a discharge of 2 LPH is placed at each row on the bed prior to planting. Before planting, the drip system is run to check uniform discharge of water from the emitters.

Mulching

Black / silver UV stabilized polyethylene mulch film 100 micron (400 gauge) thickness having 1.2 m width is used

to cover the planting beds and securing the edges of the sheet by burying in the soil. Holes of 7-8 cm diameter are made on the mulch film using a sharp pipe at recommended crop spacing.

Spacing

Capsicum is planted at a distance of 45cm x 30 cm in triangular manner

Transplanting

The healthy and disease free seedlings of 30-35 days age, 8-10 cm height with 5-6 leaves are used for transplanting. Optimum time of seedlings planting is August-September on raised beds. Planting should always be done in the evening. Irrigation is given by rose can immediately after planting till plant establishment during the first week.

Irrigation

Drip irrigation is started 10 days after transplanting. Drip irrigation is provided daily to supply 2 to 3 liters of water /m² / day depending on crop requirement and weather conditions.

Fertigation

Following water soluble fertilizer combination is provided to the plants through drip fertigation. The fertigation is provided twice a week.

Crop Stage	NPK	Dose (g)/ 500m ²
Planting till fruit setting	19 : 19 : 19 0 : 0 : 50	500 25
Fruit set until first Picking	19 : 19 : 19 46 : 0 : 0 0 : 0 : 50	500 100 250
After First picking to end of season	19 : 19 : 19 46 : 0 : 0 0 : 0 : 50	4500 500 250

Pruning and Training

Capsicum plants are pruned to retain four stems. The tip of the plant splits into two at 5th or 6th node and are left to grow. The pruning is done after 30 days of transplanting. These two branches again split in to two giving rise to four branches. The axillary buds are removed periodically resulting in bigger fruits with better quality and high productivity. The main stem of plant is tied with plastic twine to train along and tied to GI wire grid provided on the top of the plants. This is practiced after four weeks of transplanting. The new branches and plants are trained along the plastic twines.

Deleafing

The older leaves that are shaded by the new growth or touching the ground surface are removed periodically in order to reduce the fungal infections and pest accumulation. Leaves are retained to a length of about 1.0 m on the stem from the growing tip at any stage of growth.

Harvesting and Yield

Harvesting of fruits is done at weekly interval. The production of proper managed coloured capsicum under polyhouse can reach up to 100-120 tonnes/ha (10-12 kg/sqm or 4-5 kg/plant).

PARTHENOCARPIC CUCUMBER

Varieties

Parthenocarpic cucumber is cultivated under protected cultivation in order to avoid the use of pollinators due to its high cross pollinated habit. Parthenocarpic cucumber have been proven to give good results under protected cultivation in Northern Indian conditions. The following varieties can successfully be grown in

polyhouse condition:

- Hilton (C.E.V)
- Kiyan (Syngenta)
- Isatis (Syngenta)
- Multistar C.E.V)
- Deltastar (C.E.V)
- Sunstar (Rizwan)
- Kingstar (Rizwan)
- Hasan (Holland)

Nursery raising

Seedling are raised in 48 cell pro trays having drainage holes at the bottom. The growing media includes vermi-compost + sand + sterilized cocopeat (1:1:1). Seeds are planted single in each cell. The emerging seedlings are drenched with Copper-oxochloride solution (@ 3 g/lit). The seedlings are provided nutrition by drenching them with 0.2 per cent, 19:19:19 (N:P:K) plus trace elements at 15 days after germination. To prevent insect infestation, the seedlings are sprayed using Acephate (0.75g/lit) or Imidacloprid (0.03 ml/lit). Drenching the seedlings with Carbendazim or Ridomil (0.1%) on the day of planting is required for avoiding damping off and better establishment.

Bed preparation

Leveling of beds is important. Bed to bed distance should be 1.5 meters. Width of the bed is 100 cm. leaving 50 cm path in between. Height of the bed should be 20 cm, row to row spacing on bed is kept 30 cm with plant to plant distance 45 cm.

Solarization of growing beds

Disinfection of beds is done after soil preparation and application of vermicompost. Soil is wetted thoroughly with formalin 4 % solution @ 4 lit. per sqm.

The surface is covered with white and transparent polythene sheet (100 micron thickness). During process the temp. rises upto 60-70 °C. This process helps in killing weeds, harmful organisms, fungal spores, bacteria and nematodes.

Fertilizer application

Well decomposed organic manure at the rate of 10-15 kg per square meter of the bed is added and mixed thoroughly before fumigation. Commercial fertilizers containing 19:19:19, N:P₂O₅:K₂O are applied @ 7 g per sqm to the growing beds after fumigation. Two furrows 10 cm deep are made adjacent to the planting rows in the growing bed, the fertilizer mixture is applied and the furrows are closed.

Laying of drip line

One inline drip lateral with 30 cm inter-emitter distance having a discharge of 2 LPH is placed at each row on the bed prior to planting. Before planting, the drip system is run to check uniform discharge of water from the emitters.

Mulching

Black / silver UV stabilized polyethylene mulch film 100 micron (400 gauge) thickness having 1.2 m width is used to cover the planting beds and securing the edges of the sheet by burying in the soil. Holes of 7-8 cm diameter are made on the mulch film using a sharp pipe at recommended crop spacing.

Spacing

Cucumber is planted at a distance of 60cm x 60 cm in triangular manner

Transplanting

The healthy and disease free seedlings of 20-25 days age, 8-10 cm height with 5-6

leaves are used for transplanting.

- Planting time**
- July- August
 - Oct - November
 - January-February

Irrigation

Drip irrigation is started 10 days after transplanting. Drip irrigation is provided daily to supply 2 to 3 liters of water /m² / day depending on crop requirement and weather conditions.

Fertigation

Following water soluble fertilizer combination is provided to the plants through drip fertigation. The fertigation is provided twice a week.

Days after transplanting	N-P-K 19-19-19	Dose (g/500 sq.m)
0 -14 Days	19 - 19 -19	500
14 -35 Days	13 - 0 - 45 46 - 0 - 0	200 100
35-till the end of crop	13 - 00- 45 46 - 0 - 0	500 150

Pruning and Training

The cucumber plants are trained upwards retaining 2 branches for better interception of light. The main stem is pruned to 25 cm and two strong laterals are allowed to grow. If too many fruits are set at once, fruit thinning is necessary to avoid malformed and non-marketable small fruit. Such fruit should be removed as soon as possible when they are produced in bunches. Weak and unproductive lateral branches should be removed.

Deleafing

The older leaves that are shaded by the new growth or touching the ground

surface are removed periodically in order to reduce the fungal infections and pest accumulation. Leaves are retained to a length of about 1.5 m on the stem from the growing tip at any stage of growth.

Harvesting and Yield

Parthenocarpic cucumber is cultivated under protected cultivation in order to circumvent the use of pollinators due to its high cross pollinated habit, which affect the spray schedule in the polyhouse. Flowering start after 25-30 days of transplanting. First harvest is 35-40 days after transplanting. Production up to the tune of 300-400 tonnes/ha (30-40 kg/sqm) can be achieved. Under protected cultivation the growing period could be extended for the whole year and average fresh fruit yield can reach 35 kg/sqm.

Disease and pest management

a. Before sowing

1. Purchase seeds from genuine source.
2. Treat the nursery beds with 4 % formalin @ 4 lit per sqm 20 days before sowing.
3. Treat seeds with Thiram 75 WP or Hexacap 75 WP (3 g/kg seed).

b. During planting:

1. Disease free seedlings should always be transplanted.

c. After planting

1. Plant the seedlings in the centre of the holes and care should be taken so that the plants do not touch the mulching sheet.
2. Apply 3-4 sprays of Dithane M-45 (2 g/L water) or Blitox-50 or Fytolan (3g/L water) at 10-15 days interval starting 40 days after transplanting for the management of alternaria diseases.

d. Fruiting stage

1. Apply 2 sprays of Ridomil MZ (2.5 g/L water) at 10-15 days interval for the control of Buckeye fruit rot or Late Blight followed by Hexacap (2.5 g/L water) or Blitox-50 (3 g/L water) or Bordeaux Mixture (Copper Sulphate 800 g + lime 800 g + 100 L water).
2. Infested, rotten fruits and diseased plants should be picked and destroyed.

Insects

1. **Fruit borer** : Caterpillars feed on the tender foliage and flowers of plants and make holes in the fruits and feed inside. Spray carbaryl 0.1% (2 g Sevin 50 WP) or spray fenvalerate 0.01% (0.5 ml Sumicidin/ Fenval/ Agrofen 20 EC) or cypermethrin 0.0075% (0.3 ml Cymbush 25 EC/75 ml Ripcord 10 EC) or deltamethrin 0.0025% (0.9 ml Decis 2.8 EC) per lit water at flowering stage and repeat at 15 days interval.
2. **Fruit flies**: Fruit flies lay eggs on the fruits by embedding them in the pulp through the pedicel end. In May-June, when the adults start appearing, pheromone traps containing ply wood pieces soaked in 6 parts alcohol + 4 parts methyl Eugenol + 1 part malathion should be hanged to trap and kill the insects. Spray Fenthion 0.05% (50 ml Lebaycid 1000) or fenitrothion 0.05% (Sumithion/ Folithion/ Accorhion 50 EC). Collect all infested fruits regularly from the field and destroy. **Caution** : Do not harvest the crop before 15 days after spraying.
3. **Cutworms** : The dirty grey caterpillars remain hidden in the soil and cause heavy damage to seedlings by cutting the stem of young plant at ground level. Drench soil with Durmet (2 ml/litre) at the time of preparing the field for

transplanting. **Caution** : Use well decomposed FYM.

4. **Root-knot nematode:** Nematodes attack on tomato is expressed through knot-like galls on the roots which, leads to malfunctioning of roots. The leaves turn yellow and growth becomes stunted. The infestation is noticed in patches in the field. Symptoms of water stress like leaf cupping and temporary day time wilting are observed. **Caution** : Do not grow other solanaceous crops like capsicum, chillies, Brinjal, etc. in the following season. Use nematode free nursery (gall free seedlings) to check the spread of nematodes. Apply carbofuran granules (Furadan 3 G @ 5-10 g/m²) in beds.

Disorders

1. **Blotchy ripening, Vascular browning, white wall, grey wall:** Caused due to the deficiencies of potassium and Magnesium. Apply recommended dose of KCl or spray 0.2% solution of K₂SO₄ along with 1.0% solution of MgSO₄ as foliar spray.
2. **Fruit cracking:** Caused due to Boron and Calcium deficiency. Cracking appears all over the fruits. Both seedlings and plants should be sprayed with 0.3-0.4% solution of borax. Apply borax @ 20-30 kg/ha. Apply recommended dose of lime or single spray of 0.5% CaCl₂ solution at the time of fruit development.
3. **Blossom end rot:** Caused due to the deficiency of Calcium. Lesions appear at blossom end of the fruit while it is green. Water soaked spots appear at the point of attachment of the senescent petals. It enlarges rapidly to 1 cm or more in diameter. The affected portions of the fruit become sunken,

leathery and dark coloured. Increasing amount of N is conducive to the occurrence of this disorder. Single spray of 0.5% CaCl₂ solution at the time of fruit development.

4. **Catface:** The fruits with Catface are characterized by the distortion of the blossom end of the fruit. Such fruits have ridges, furrows, indentation and blotches. It resembles blossom end rot. Single spray of 0.5% CaCl₂ solution at the time of fruit development.

Cost Economics for Protected cultivation in polyhouse

Sl. No.	Particulars	Details		
	Crop	Tomato	Capsicum	Cucumber
	Area (ha)	500 sqm	500 sqm	300 sqm
	Crop period/year	8 month	8 month	6 month
A	Spacing (RR cm X PP cm)	60 x 45	45 x 30	60x60
	No. of Plants/sqm	2.64	3.56	2.8
	Yield per Plant /sqm	12	5	5
	Total Yield (Ton /ha/year)	316.8	178	144.0
	Sale Price (Rs/Kg)	15	40	20
	Variable Costs (Rs / Sqm)			
	Land Preparation	2000	2000	1500
	Fertilizer	2500	2500	1500
	Irrigation Costs	1000	1000	500
	Seed Costs	2000	2500	5200
	Chemical Costs	1200	1200	1200
	Soil solarization	500	500	500
B	Nursery management	1200	1200	1200
	Mulching	6000	6000	4000
	Labour	21000	21000	12000
	Interest @ 10%	3260	3260	3260
	System maintainance cost	7000	7000	5000
	Other Variable Costs	2500	2500	1500
	Total Variable Costs (Rs)	50160	50660	37360

Sl. No.	Particulars	Details		
C	Fixed Costs @ Sqm			
	b. Greenhouse	45000*	45000*	45000*
	c. Drip Irrigation System	5000	5000	5000
	d. Sprinkler Irrigation System			3000
	Total Fixed Costs (a+b+c+d) Rs	50000	50000	13000*
B+C	Total Cost of Production (Variable + Fixed) Rs	100160	100660	50360
	Gross Income(Rs)	237600	356000	86400
	BC Ratio	2.37:1	3.53:1	1.71:1
	Pay Back Period (Years)	6Year	5Year	5Year

Protected cultivation of tomato, capsicum and parthenocarpic cucumber in poly house (500 sqm area) is given as follows:

The varieties tested at CISH, Lucknow:

Tomato: Naveen, Sartaj

Capsicum: Bharat, Indra

Parthenocarpic cucumber: Isatis, Kian

HI-TECH NURSERY UNDER GREENHOUSE

Over the years, the productivity and quality of several fruit crops have continued to remain much below the potential. There are various factors, which contribute towards this low productivity. One of the factors is poor quality seed and planting material. Genuine planting material is the basic requirement for quality production. Although a large number of nurseries and many seed companies are operative, there is an acute shortage of quality seed and planting material. As large number of horticultural crops are propagated through vegetative methods. Although vegetative methods of propagation help in multiplying true-to-type plants, there is high risk of transmission of viral diseases from one

generation to other. Sometimes unscrupulous nurserymen even sell seedling plants in place of graft when demand is high. The quality seeds are also in short supply and often do not meet the standards. Therefore, in such a scenario, the advent of concept of hi-tech nursery becomes important. Unless high quality of planting material is made available, the technologies will not have the desired impact. Variations are also observed in productivity and quality amongst the trees of variety. Moreover, the plants supplied by nurseryman are not true-to-type variety. It is therefore necessary that the best trees are selected and used as mother tree for future multiplication.

Advantages

- Year round propagation.
- Control over seed germination, better growth and success.
- Better possibility of establishment.
- Cheaper and quick transport.
- Uniformity and purity of propagated plants
- Genuineness of planting material
- Acclimatization of micropropagated plantlets
- Economical production due to less mortality
- Disease and insect free planting material

Selection of Mother Plant

Selection of mother plant is to be given top priority as it decides the success of propagation including production and productivity. The scion material should be taken from the tree fulfilling all the scientific criteria for best performance.

- The parent plant must have been tested

for its performance over a number of years.

- It must be free from transmittable diseases and in a healthy condition.
- The fruit shape, size and quality must conform to the typical specification of the variety.

Establishment of mother plants

With the objective of making available enough scion shoots, new mother tree blocks need to be established by grafting/budding on a suitable rootstock and planting at a higher density. These should be maintained uniformly by application of manures and fertilizers, irrigation, weeding and inter-culture operations, training and pruning and plant-protection measures.

Quality of media

- Firm and dense to hold the cuttings or seeds in place during rooting or germination. Volume fairly constant no excessive increase or shrinkage on wetting/drying.
- Retain enough moisture to avoid frequent watering
- Free from weed seeds, nematodes or pathogens
- Porous so that excess water drains away, permitting adequate aeration.
- Should not have high salinity
- Should be capable of being pasteurized with steam or chemicals without any harmful effects.
- Must provide adequate nutrients in situations when plants remain for a long period.

Composition of root media

- Soil : 1 Part
- Sand : 1 Part
- Cow dung manure/vermicompost : 1 Part
- Coco peat/rice husk : 2 Parts

Mechanization of Hi-tech Nursery

Mechanization in nurseries is required for their optional use and efficiency. There is a need for developing equipments, which can pulverize, mix and sterilize root media in protrays. Therefore, initial support for establishing such nurseries which are equipped with modern facilities for microirrigation, greenhouse is required.

Wedge grafting

- Wedge grafting is a relatively easy method of propagation.
- Success percentage is higher than that of budding.
- The plants grafted with wedge method takes less time (9-12 days) for sprouting and plant gets ready for sale within five months from day of grafting operation.
- The grafted plants showed very high field establishment on account of undisturbed tap root system.
- The major advantage of this technique is that, plants get higher success rate with the help of polythene cap even at low temperature (during winter season).
- After grafting, if scion dies for any reason, the split portion is beheaded and rootstock can be used for further grafting.

Steps

- Prepare the rootstock seedlings by removing side shoots frequently. Newly emerged stock shoots of 1 year old rootstock, seedlings having bronze coloured leaves are selected for wedge grafting.
- Select 5-7 months old seedlings having straight growth and thickness of 0.8 to 1.25 cm in diameter.
- For high success temperatures of 30-

32°C are ideal.

- Scion wood to be used is defoliated 7-10 days prior to grafting.
- In winter season defoliation can be done on the same day of detaching.
- Leaf blades are removed leaving the petioles from the scion sticks, wrap them in polythene and store in cool place preferably at 5-6°C.
- Dip the scion sticks in 0.1% Bavistin solution before storing.
- Thickness of stock shoot and scion stick should be the same.
- After the grafting process is over, it is secured firmly using 1.5 cm wide, 4.5 cm long and 200 gauge polyethylene strip without leaving any air pocket.
- This can be performed in open field or containers.
- With use of poly and net house, grafting operation can be continued almost year round.
- Sterilize the budding knife and other tools in 1-2% sodium hypochlorite sol.
- After 5 months the plants are shifted in open for few days before these are ready for sale.

Criteria for selection of mother plants

- Mother plants of the variety should be genetically true to type.
- The plants should be healthy and free from any diseases, pest infestations and physiological disorders.
- The plants should have known pedigree records regarding bearing potential, fruit quality and problems, if any.
- The plants should be precocious and prolific bearer.

Criteria for selection of rootstocks

- Dwarfing / semi-dwarfing in nature

- Compatibility with the known commercial varieties
- Resistance/tolerance to biotic and abiotic stresses.
- Rootstocks should have well developed root system.
- Easy to propagate by vegetative means

Sanitation for better success

- For all propagation work, it is necessary to use clean growing medium, sterile containers, a sanitized bench, and pathogen-free plant materials.
- Soil pathogens may contaminate the soil mixture. Small outbreaks of diseases can be controlled by using appropriate fungicides.
- Propagating media can easily be pasteurized by steam, chemicals or solar radiation.
- Expensive equipments and training of personnel are necessary for pasteurization or sterilization of propagating media.
- A temperature of about 71 °C for 30 minutes is considered sufficient to kill almost all pests.
- Drenching the medium with certain fungicides, such as Captan, Fytolan or Brassicol (1 g/litre water), is also useful in eliminating pathogens from the medium.
- Besides a clean and sterile medium, disinfection of pots, flats, greenhouse benches, watering cans and other garden tools, general cleanliness is also necessary to avoid recontamination of the medium.
- Pots, flats and propagating benches can be sterilized with steam, boiling water or 2 per cent formaldehyde.

PROTECTED CULTIVATION OF HORTICULTURE CROPS

Raising planting materials (mango, guava, aonla, bael) under protected condition (unit size 500 sqm). Seventeen thousands plants can be raised in 500 sqm

Fruit crops		Mango, guava, Aonla and bael		
Spacing of polyethylene bags (Saplings)		5.0 cm x 5.0cm		
		Greenhouse – 500 sqm		
Sl. No.	Description	Quantity	Rate (Rs./Unit)	Amount spent (Rs.)
A.	Seeds			
	a. Mango (22000 stone)	14.0 bags	275/bags	3850.00
	b. Guava	0.5 kg	400/kg	200.00
	c. Aonla	1.0 kg	800/kg	800.00
	d. Bael	2.0 kg	60/kg	120.00
	Sub Total			4970.00
B.	Polyethylene bags (400 gauge)			
	a. 25cm x 15cm (300 gauge thickness)	70.0 kg	90.0 /kg	6300.00
	b. 30cm x 15cm (100 gauge thickness) mango	100.0 kg	100.0 /kg	10000.00
	c. Polyethylene sheet for cap	10.0 kg	100.0/kg	1000.00
	Sub Total			17300.00
C.	Preparation of potting mixture			
	a. FYM	01 lorry	7500/lorry	7500.00
	b. Soil	05 lorry	200/lorry	1000.00
	c. Sand	01 lorry	300/lorry	3000.00
	Sub Total			11500.00
D.	1. Soil sterilization with formalin	25.0 lit.	250/lit.	6250.00
	2. Polyethylene sheet (white 100 micron).	20.0 kg	80.0/kg	1600.00
	Sub Total			7850.00
E.	Fertilizers			
	a. Urea	85.0 kg	5.17/kg	439.45
	b. SSP	170.0 kg	3.68/kg	625.60
	Micro nutrient as an when required	-	-	1000.00
	Sub Total			2065.00
F.	Labour			
	a. Filling of polyethylene bags (including preparation of potting mixture)	30 mandays	200/mandays	6000.00
	b. Seed sowing (in poly bags)	20 mandays	200/mandays	4000.00
	c. Shifting and arrangement of poly bags in greenhouse.	10 mandays	200/mandays	2000.00
	d. Scion defoliation	10 mandays	200/mandays	2000.00
	e. Grafting operation	17000 nos.	1.0/graft	17000.00
	f. Management /supervision etc.	2 men/month	3500/month	72000.00
	Sub Total			103000.00
	Grand Total		A+B+C+D+E+F =	1,46,685.00

Cost per plant with polyethylene bag

Guava	-	Rs. 8.60/ plant
Aonla	-	Rs. 8.60/ plant
Bael	-	Rs. 8.60/ plant
Mango	-	Rs. 10.0/ plant

Path Forward

The quality of produce from open

fields, often fail to compete stringent international standards. Therefore, there is a strong need to standardize and popularize protected cultivation in agroclimatic region specific locations for harnessing the benefits of protected cultivation with less energy requirement. To achieve this, low cost greenhouse technologies with less energy requirement for small and marginal farmers are needed to be developed.



Types of protected structures: Polycarbonate polyhouse, polyhouse (fan-pad), nethouse



Tomato production under polyhouse



Production of colored capsicum under polyhouse



Production of parthenocarpic cucumber under polyhouse



Year round nursery production under polyhouse



Production of other high value crops under polyhouse
(muskmelon, watermelon and strawberry)

Physiological Disorders under climatic aberrations



Fruit cracking in tomato

Cat Face in tomato



Blossom end rot in tomato

Sun scalding in tomato



Manganese deficiency in tomato leaves

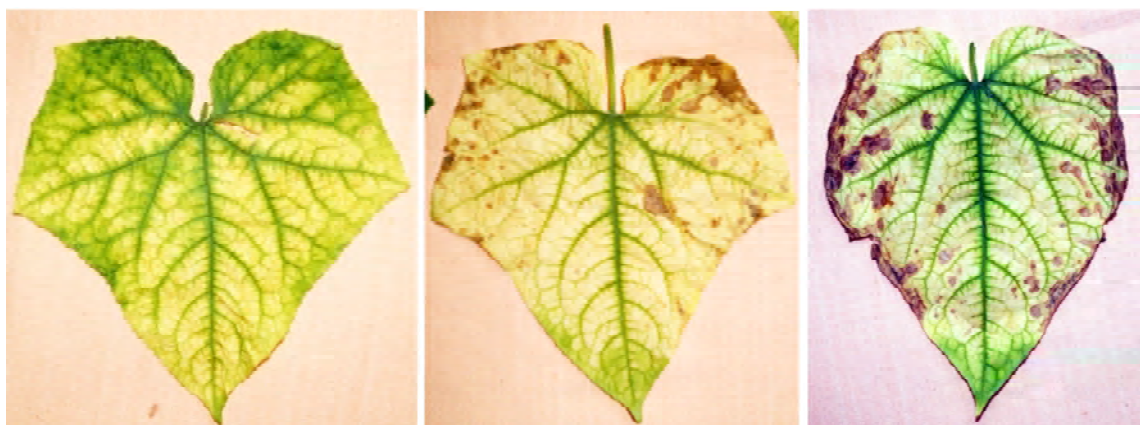
Physiological Disorders under climatic aberrations



Deformed fruits in capsicum due to moisture and temperature fluctuation



Healthy and deformed fruits in cucumber due to moisture and temperature fluctuation



Micronutrient deficiencies in cucumber iron, magnesium & potassium



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