

Protected Cultivation Technology for Arid & Semi Arid Region

P.P. Singh, A.K. Verma, S.K. Maheshwari, D.K. Sarolia and M.K. Jatav

Introduction

Protected cultivation practices can be defined as a cropping technique where in the micro environment surrounding the plant body is controlled partially or fully as per plant need during their period of growth to maximize the yield and resource saving. Protected structures can play important role to minimize the impact of temperature fluctuation, over/under precipitation, fluctuating sun shine hour and infestation of disease and pest. The controlled environment can be utilized for growing early season /off-season vegetables and high value vegetables. This may become relevant to those farmers having small land holding who would be benefitted by a technology, which helps them to grow more crops each year and save them from adverse situation. Vegetable crops are very sensitive to climatic vagaries and sudden rise in temperature as well as irregular precipitation at any phase of crop growth can affect the normal growth, flowering, pollination, fruit development and subsequently decreased the crop yield. Apart from that high input cost and higher labor wages make vegetable cultivation less profitable under open field condition. Again, in the present scenario, more people are demanding early season/off-season vegetables and high value vegetables at higher price which are not possible to grow under open field situation.

Present status in world: In world, China has the largest area (2,760 thousand hectares) under greenhouse cultivation followed by Korea having 57.44 thousand hectares (Nair and Barche, 2014). The advent of protected cultivation technology in India materialized during the early nineties, post globalization.

India: India is the second largest producers of vegetable in the world, however as per medical council of India, the production is much less than the requirement

if balanced diet are to be provided to every individual. The advent of protected cultivation technology in India materialized during the early nineties, post globalization. In India, the area under protected cultivation faced with constraints of land holdings, rapid urbanization, declining crop production, declining biodiversity and ever increasing population, demand for food, especially vegetables has increased manifold and protected cultivation has offered a new dimension to produce more in a limited area. Today Dutch protected cultivation is one of the most intensive farming systems in the world with high levels of output by using the latest technologies.

Table 1: Greenhouse area (ha) under world

Present status in world	Greenhouse Area (ha)
China	27,60,000
Korea	57,444
Spain	52,170
Japan	49,049
Turkey	33,515
Italy	26,500
Mexico	11,759
Netherlands	10,370
France	9,620
United States	8,425

Table 2: Leading states in protected cultivation in India

S. No.	State	Area (in ha)	Crops
1.	Maharashtra	8000	Carnation, gerbera, rose, capsicum
2.	Karnataka	1000	Roses, gerbera, carnation, vegetable seed production and nursery raising of vegetables
3.	Himachal Pradesh	700	Capsicum, carnation, gerbera, tuberose
4.	Punjab	500	Vegetable crops
5.	Uttarakhand	300	Gerbera, capsicum
6.	Tamil Nadu	100	Floricultural crops
7.	North-Eastern States	800	Floricultural and vegetable crops

Gaps in prevailing system: Energy efficient cultivation continues to be achieved through precision equipment and protocols. While, the gap between demand and supply of most of horticultural crops remains wide and country plans to double production of horticultural crops by 2022, protected cultivation technology holds the key to meet the targets green house. Protected cultivation technology requires very careful planning, maintenance and management about timing of production and moreover, harvest time to coincide with the shortage period of availability of vegetables and high market prices, choice of varieties adopted to off season environments, and able to produce higher and economical yields of

high quality produce etc. Vegetable farming in agri-entrepreneurial models targeting various niche markets of the big cities of the country is regularly inviting attention of the vegetable growers for diversification from traditional ways of crop cultivation to such modern methods. Even the 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.

Methods of protected cultivation

1. Green house/Polyhouse/Net house/Shade house
2. Low Tunnels/row covers
3. Plastic low tunnel
4. Lath houses
5. Hot beds
6. Cold frames
7. Cloches

Greenhouses

A greenhouse is a framed or an inflated structure covered with a transparent or translucent material in which crops could be grown under the conditions of at least partially or fully controlled environment and which is large enough to permit persons to work within it to carry out cultural operations.

Types of Greenhouses

To the extent of environmental control, the existing green house structures can be classified as:

- High cost (fully controlled greenhouse)
- Medium cost (partially controlled)
- Low cost (naturally ventilated)
- **Other classifications**
 - The greenhouse can also be classified based on type of structures, type of glazing, number of spans, environmental control etc. The various types are as follows.

- **Classification as per type of structure**

- a. Quonset type
- b. Curved roof type
- c. Gable roof type

- **Classification as per glazing**

- a. Glass glazing
- b. Fiberglass reinforced plastic glazing
 - i. Plain sheet
 - ii. Corrugated sheet
- c. Plastic film
 - i. Ultra violet stabilized low density poly ethylene
 - ii. Silpaulin

- **Classification based on number of spans**

- a. Free standing or single span
- b. Multi span or ridge and furrow or gutter connected

- **Classification based on environmental control**

- a. Naturally ventilated
- b. Passive ventilation

Principle of greenhouse

A greenhouse is generally covered with a transparent material such as polythene or glass. Depending upon the cladding material and its transparency major fraction of sunlight is absorbed by vegetable crops and other objects. These objects in greenhouse in turn emit long wave thermal radiations for which cladding material has lower transparency. With the result, solar energy is trapped and raises the temperature inside the greenhouse. This is popularly known as greenhouse effect. This rise in temperature in greenhouse is responsible for growing vegetable in cold climates. During summer months, air temperature in greenhouse is to be brought down by providing cooling device. In commercial greenhouses besides temperature-controlled humidity, carbon dioxide, photoperiod, soil temperature, plant nutrients etc. facilitate round the year production of desired vegetable crops. Controlled climatic and soil conditions provide an opportunity to the vegetable crops to express their yield potentials

• Components of Green house

Protected cultivation has two major components of technology. One is the infrastructure involving frames, cladding materials, irrigation system, tools, implements, other engineering inputs and another is crop production technology.

Infrastructural inputs ensure optimal light, air temperature, water and plant growth requirements. This optimal aspect of climatic parameters involves simple to most advanced engineering inputs such as automation, etc. to regulate several parameters such as ventilation which is one of the most important components in a successful greenhouse production. A major problem with conventional designs of greenhouses is the concentration of heat within the covered structures, which needs to be either expelled or neutralized through energy-intensive cooling facilities. This problem has been overcome by designing naturally ventilated greenhouses where the temperature can be maintained at the desirable level without consuming any energy. Importance of cladding materials in protected cultivation can hardly be overemphasized. Their quality and cost are important besides certification. Micro irrigation and fertigation involves a lot of science and technology, demanding research for continuous improvement. It is the engineering aspect of the protected structure which provides plants optimal conditions to grow normally. Another aspect of protected cultivation is crop production technology which involves development of high-yielding varieties and hybrids of crops suitable for protected cultivation.

Lath House

Lath house provides outdoor shade and protect container grown plants from high summer temperature, high light intensity. They reduce moisture stress and decrease the water requirement of the plants and thus these are useful for protecting young seedlings. During summer, overhead sprinklers are used for cooling down the temperature inside of shade.

Cold frame

These are available with metal or wooden frames with glazed or solid sides and are useful for hardening off plants.

Hot bed

Reinforced polyester plastic is also used for frame. It is light in weight, easy to handle and admits light, which however, is likely to decrease with age. Hot beds are headed with the help of different heating systems like hot air, hot

water and electricity, which are adopted depending upon availability and cost, systems.

Shade net House

Shade nets are available in different shade percentages or shade factor i.e. 15%, 35%, 40%, 50% 75% and 90% (for example 35% shade factor means - the net will cut 35% of light intensity and would allow only 65% of light intensity to pass through the net).

Traditional cloche

Wire frame with sheets of glass used for establishment of transplants and hardening off and overwintering of autumn sown crops. It helps in warming soil prior to sowing and excludes some pests e.g. birds and cats.

Vegetables grown under polyhouse

Tomato

Beefsteak varieties: FA-574, FA-180 and FA-514

Big fruited varieties: Naveen, Arka Vardan, Vishal, Delphi, Astona, Cornos, Shanmon

Cluster type varieties: HA-646, FA-556 and FA-521

Cherry tomato varieties: T-56, NS Cherry-1 &2, BR-124, HA-818

Sweet Pepper

Red: Heera, Bharat, Indira, Bombay, Jamini, Pusa Deepti

Yellow: Tanvi, boyaton, Orobellee, Golden Summer, Nun-3020

Cucumber

Satis, Alamir, Nun-9729, Kian

Pusasanyog, Priya and Poinsett can also be grown inside polyhouse.

Production Technology of Tomato under Greenhouse

Greenhouse cultivation of vegetables offers distinct advantages of quality, productivity and favourable market prices to the growers. Vegetable growers can substantially increase their income by greenhouse cultivation of vegetables in off season as the vegetables produced in the normal season generally do not fetch good returns due to large availability of these vegetables in the market.

Climate requirements

Temperature and light intensity affect fruit set, pigmentation and nutritive value of the fruits. Critical factor in setting fruits of the tomato is the night temperature, the optimum range being 16°C to 22°C. Fruits fail to set at 12°C or below. Fruit set is also reduced markedly when average maximum day temperature goes above 32°C and average minimum night temperature goes above 22°C. At temperatures below 10°C, red and yellow colours do not develop. The ideal range for development of both red and yellow colours is 18-25°C. Under greenhouse conditions tomato crop can be grown for long duration (10-12 months) by cooling the greenhouses during summer months (April to July) and by heating the greenhouses during peak winter (December and January) months.

Preparation of soil, nursery raising and planting

In northern plains the tomato crop is planted from first August to second week of September under greenhouse conditions. August or September planted crop is continued upto June or July under climate controlled greenhouse conditions. If the greenhouse is naturally ventilated then the crop can be grown up to April or May months. Nursery for greenhouse tomato is raised under protected structure mostly in soilless media in plastic trays to produce disease free and virus free seedlings. The seedlings are ready for transplanting within 28-30 days under soil-less media. Healthy seedlings are transplanted at a planting distance of 60 x 45 cm mostly under drip irrigation system for efficient use of water and fertilizers for long duration cultivation of tomato crop and low pressure drip irrigation system can also be used for greenhouse tomato cultivation. Transplanting is mostly done in the early morning or late evening time for better establishment of the seedlings.

Training, pruning and trellising

Greenhouse grown tomatoes needs regular trellising, training and pruning of plants. Single stem (main) should be retained by removing all side shoots or suckers that develop between leaf petioles and the stems. Usually in early stage shoots are removed by snapping them off, not cutting them by knife, blade or scissors, as diseases mainly the virus (T.M.V.) can be transmitted from one plant to other. Plants are supported by plastic or binder twine, loosely anchored on the base of plants with the help of plastic clips or directly by non-slip loop and to overhead support wires (11 to 12 gauge) running to the length of the row of the bed. Overhead wires are fixed normally 8 to 9 feet above the surface of the bed and are anchored firmly to the support structure. Twine should be wrapped clockwise around the vine as it develops with one complete swirl every three leaves. The vine should be supported by the twine under the

leaves, not the stems of the flower truss or fruit clusters. Twine is not wrapped around the growing tip otherwise the tip may break. When the plants reached overhead supporting wires, untie the twine (or take down the twine) from the twine roll after unlocking it to take down the vines at least 2 to 3 feet in every 15-20 days gap. Vines with twines are moved in one direction with twine roll in one row on the overhead wires and in opposite direction in the adjacent row. The plants must be pruned and trellised on regular basis for 10-11 months life cycle of the tomato crop in greenhouse and as a result plants are 30-35 feet longer in their 10-11 months life cycle of cultivation. Clearly, the greenhouse will not be able to accommodate the plants vertically. As fruits mature on the lower parts of the vines, pinch off older leaves below the fruits. This will, provide air circulation, which helps to reduce the incidence of the diseases and opens vines up for spraying and harvesting. Removal of excess fruits will also result in larger tomatoes at harvest that can fetch good price.

Pollination requirement in green house

Although tomato is highly self-pollinated crop but aided pollination of flowers is generally needed in the green house grown tomatoes due to limited air movement and high humidity. In several countries bumble bees are being used as a pollinator for the green house tomato crops. Bumble bees are the perfect pollinators, even under environmental stress condition (i.e. under low and high temperature conditions). But in several countries an electric or battery –powered vibrators are being used to vibrate flowers cluster above the area where they originate from the stem. The vibration will release sufficient pollens necessary for pollination. This practice is done twice a day (10:00 AM to 11.00 AM and 2.0-3.0 PM). Flowers are vibrated or shaken every day. Air from a mistflower also has been found effective in pollinating tomatoes inside the protected structures. If tobacco mosaic virus (T.M.V) has been a problem the vibrator should be wiped after each use with a clean cloth.

Fertigation

Application of 350:350:350 kg NPK/ha in the form of water soluble fertilizers through fertigation at weekly intervals is recommended for getting maximum productivity and best quality of tomato under cost effective greenhouse.

Cooling and heating of the greenhouses

Most of the climate controlled greenhouses are having evaporative cooling system. In northern plains of our country cooling is done from September to October and from April to June months. Evaporative cooling system is quite effective when the relative humidity in the atmosphere is below 40%. Heating

of the greenhouses can be done from 15th of December to end of January, to increase the temperature of the greenhouse during nights, so that the temperature cannot fall below 14°C. Heating and cooling of the greenhouses are required during growing of tomato for a period of 10-12 months.

Harvesting and post-harvest handling of fruits

Harvesting of tomato fruits is a continual process throughout the growing cycle. Generally, most of the varieties are ready for first picking 75 to 85 days after transplanting. Big size tomato (slicing tomato) fruits are harvested singly with attached calyx, and are graded and packed according to grades. Under greenhouse conditions tomato can yield 100- tonnes/ha. During the summer months harvesting should be done in the early morning or late evening to avoid post-harvest losses.

Plant protection in greenhouse

Mostly greenhouses are designed to minimize or eliminate insects and diseases problems so that plants can be grown pesticide free under many conditions. Generally, all four sides of greenhouses are covered with insect proof nylon net of 40 to 50 mesh size to prevent insects, including white flies, thrips, aphids etc. Preventing insects from entering the protected structures is the best way of controlling virus and insect problems. However, if required, one or two sprays of insecticides can be done on need base. One spray of metasystox @ 1.5 ml/litre of water is done 10 days after transplanting of the crop. If there is severe problem of mites, we can spray dicofol @ 2.0 ml/litre of water. Sometimes white flies or thrips entered in greenhouses, yellow and blue trappers are used for trapping of such insects. For control of root knot nematodes and other soil borne pathogens, soil sterilization is most effective and it is done by applying the formaldehyde (37%), one month before transplanting of the crop. Sometimes if some plants are infested with T.M.V, such plants are to be removed immediately to avoid further spread of virus inside the greenhouse.

Protected Cultivation of Capsicum

Capsicum, also known as sweet pepper, bell pepper or Shimla Mirch is one of the popular vegetables grown throughout India. Capsicum is a cool season crop, but it can be grown round the year using protected structures where temperature and relative humidity (RH) can be manipulated. This crop requires day temperature of 25-30°C and night temperature of 18-20°C with relative humidity of 50-60%. If temperature exceeds 35°C or falls below 12°C, fruit setting is affected. The traditionally grown green capsicum, depending upon variety and season, usually yields 20-40 tons per hectare in about 4-5 months.

In greenhouse, the crop duration of green and coloured capsicums is about 7-10 months and yields about 80-100 t per hectare.

Nursery raising

Good quality seeds are required for producing better seedlings. The seedlings are raised in pro-trays of 98 cells or cavities. About 16,000 to 20,000 seedlings are required to plant one acre for which 160-200 gm of seeds is required. The pro-trays are filled with sterilized coco-peat and seeds are sown, one seed per cell to a depth of $\frac{1}{2}$ cm and covered with the same media. The filled trays are stacked one above the other and covered with plastic sheets till germination of seeds. Seeds germinate in about a week's time after sowing. The trays are shifted to net house/ polyhouse and lightly watered. After 15 days of sowing, Mono ammonium phosphate (12:61:0) (3g/L) and 22 days after sowing 19:19:19 (3g/L) solution has to be drenched. The seedlings in protrays are drenched with COC 3g/L before transplanting. The seedlings will be ready for transplanting in 30-35 days. Spray imidacloprid @ 0.2 ml/L and chlorothalonil @ 1gm/L before transplanting of seedlings. Always add about 0.3 ml/L of wetting agent per liter of water with each spray of pesticide.

Land preparation

The land should be thoroughly ploughed and soil should be brought to fine tilth. Well decomposed organic manure at the rate of 20-25 kg per sq. mtr is mixed with soil. On application is sufficient to grow three capsicum crops successively. Raised beds are formed after bringing soil to fine tilth. The bed size should be 90-100 cm wide and 15-22 cm height. Between the beds walking space of 45 cm to 50 cm need to be provided.

Fertilizer application

A basal fertilizer dose of 20:25:20 NPK is required per acre and is applied to the beds uniformly before transplanting in the form of 80 kg calcium ammonium nitrate, 125 kg super phosphate and 32 kg murate of potash or 40 kg sulphate of potash.

• Application of neem cake and microbial bio-control Agents

Fifteen days before transplanting, neem cake has to be enriched with bio agents like *Trichoderma harzianam* and *Pseudomonas lilacinous*. Neem cake of about 200 Kg is powdered and slightly moistened. *Trichoderma harzianam*, *Pseudomonas lilacinous* and *Paecilomyces chilmidosporia* each of two kg are mixed thoroughly to the neem cake. The mixture is covered with wet gunny bags or dry grass and left for 8-10 days. Avoid direct exposure to sunlight and rainfall. After 10 days, this enriched mixture of neem cake and bio-agent along

with 600 kg of neem cake has to be applied uniformly to the beds for an area of one acre. This is highly useful to reduce the problem of soil borne pathogens and nematodes. *Azospirillum* or *Azotobacter* or VAM which is a nitrogen fixing bacteria can also be applied to the growing bed.

Mulching and Spacing

Black polyethylene non-recycled mulch film of 30-100 micron thick, 1.2 m wide, is used to cover the planting beds. Holes of 5 cm diameter are made on the polyethylene film as per the recommended spacing (45cm x 30cm). The planting beds are covered with the film by securing the edges of the sheet firmly in the soil. Mulching practice conserves water, controls weeds and reduces infestation of pests and diseases and results in higher yield and good quality produce.

Transplanting

The planting beds are watered to field capacity before transplanting. Seedlings of 30-35 days old are used for transplanting. Care should be taken to see that no damage is occurred to roots, while taking out the seedlings from individual cells of portray. Seedlings are transplanted into holes made in polyethylene mulch film at a depth of 5 cm. After transplanting, seedlings are drenched with 3 g/L copper oxy chloride or 3 g/L captan or 2 g/L copper hydroxide solution to the base of seedlings at the rate of 25-30 ml per plant. Watering the mulched beds daily during afternoon by using hose pipe for a week continuously is essential to avoid mortality due to heat trapped by mulch sheet.

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. These two branches again split in to two giving rise to four branches. At every node the tip splits into two giving rise to one strong branch and one weak branch. The pruning is done after 30 days of transplanting at an interval of 8 to 10 days, resulting in bigger fruits with better quality and high productivity. The capsicum plants can also be pruned to two stems and same level of yield can be maintained.

The main stem of plant is tied with four 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.

Drip irrigation and Fertigation

Drip irrigation is given to provide 2-4 liters of water per square meter per day depending on the season. Water soluble fertilizers are given through fertigation for entire crop growth period, starting from third week after transplanting. Fertigation is to be given twice a week as recommended in below.

- Required fertilizer dosage per fertigation (kg/ac) 19:19:19 4 kg
- Potassium Nitrate 1.5 kg
- Calcium Nitrate 1.5 kg
- Capsicum crop is sprayed with water soluble fertilizers like potassium nitrate and calcium nitrate at every 3 weeks interval after 2 months of transplanting @ 3g/l as foliar application.

General Management of pest and diseases

Pests and diseases remain the greatest challenge in Tomato production. Appropriate and timely management makes all the difference between good production, poor production or total crop failure. Proper identification of the pest and disease is critical in a control strategy. The general principles in pests and disease management include:

- **Practicing crop rotation.** Observe minimum two-year rotation program.
- **Planting resistant varieties** - Use certified disease-free seed treated with an approved fungicide to control seed rots and post emergence damping off
- **Field hygiene**-old crop should be removed from the fields, control weeds and crop debris since these are source of pests and diseases. Staking and pruning is also key to disease incidence reduction.
- **Using proper crop production practices** that provide the right growing conditions for plants (sufficient water and balanced fertilization), particularly when crops are young. Strong healthy plants are more likely to withstand pests and diseases.
- **Irrigation management**; poor irrigation timing and scheduling may lead to disease, overhead irrigation in the evenings can encourage early blight.
- **Ensure regular crop scouting** for pest and disease as well as weed and nutrient deficiencies. Proper pest and diseases identification is the first and critical step in their management. This helps to detect problems early and take control measures on time.

- **Agronomic practices:** It includes nutrient management, irrigation, support, pruning, weeding, pest and disease management, harvesting.

Harvesting and yield

Early morning hours are best suited for capsicum harvest. Green capsicum can be harvested at 55 to 60 days after transplanting, yellow capsicum at 70-75 days whereas red capsicum at 80-90 days. Fruits can be harvested once in 3 to 4 days. Yellow and red fruits can be harvested when they have gained 50-80 per cent of the colour development. After harvest fruits should be kept in cool place and avoid direct exposure to sunlight. The fruits should be handled carefully by adopting clip harvest technique and scuffing should be minimized. The average yield of capsicum per acre is 30-40 tons.

Protected Cultivation of Cucumber

Cucumber known as *khira* in hindi, is an important summer vegetable crop. Green house cucumbers are parthenocarpic (produce fruit without fertilization of ovules) and the fruit are usually seedless and does not require peeling, when ready for harvest, cucumbers are usually eaten as in salads.

Seed requirement: The amount of seed will be determined by the spacing used. A plan density of 1-2.5 plants/m² is recommended for most regions.

Nursery management: Trays can be used for growing seedlings. Watering will be done lightly using a watering can and timed in the morning to avoid conditions conducive for the development of diseases. It will take about a 20 day before the seedlings are ready for transplanting.

Transplanting: The seedlings need about 20 days of growth before they are ready for transplanting. Transplanting is best done in the evening when the weather is cool. Transplant directly into already prepared holes Spacing ranges from 90x45 cm, or 90x60 cm depending on soil condition and water availability.

Irrigation: Maximum yields and fruit quality will be realized only if the plant receives adequate and timely moisture when fruit begins setting and maturing. Depending upon the soil type and growth conditions, approximately 25-50 mm of Water per week is needed to obtain high quality cucumbers.

Nutrient management

For growing cucumbers in greenhouses with soil, add as much of the required calcium and phosphorus as possible as a base dressing, because these nutrients store effectively in the soil and their absence from liquid feeds prevents most clogging problems of the irrigation system. Provide calcium in the form of finely ground calcite lime @ 800kg/ha and phosphorus in the form of super phosphate

@ 250 kg/ha. Also, supply a good portion of potassium sulphate @500kg/ha and magnesium sulphate @ 250kg/ha. The ratio of potassium to magnesium in the soil should be 2:1. For supply of nitrogen, pre plant application of ammonium nitrate @150kg/ha. Make the final decision on the base fertilization after receiving the soil test results. To correct micro-nutrient deficiencies, foliar feeds can be applied alongside the regular pesticide applications. Avoid excessive Nitrogen; it leads to excess vegetative growth, poor fruit set, smaller fruits, hollow fruits and poor keeping quality.

Weed Control

Weed control in a soil system is very much like cultivation in the field. However, fumigation will reduce the requirement for weed control. Cultivation can begin when weeds and grasses are very small, and should be done as shallow as possible to reduce root damage. Cultivation is usually accomplished by running a roto tiller between the rows. Soilless systems normally do not require weed control programs because the system itself usually prevents weed growth.

Trellising, training and pruning: Several training systems exist for net house and greenhouse cucumber. The basic principle in developing a training system is to uniformly maximize the leaf interception of sunlight throughout the house. The selection of a system will largely depend on the greenhouse facility, the production system, and grower preference. The most common pruning system is vertical cordon, which allow only one main stem to develop by pruning all lateral vines the main stem is allowed to run vertically on support nylon cord or twine to the overhead crop support. Continue to remove all lateral vines on the main stem throughout the life of the crop. The fruits on the base 30 inches of the main stem should be pruned off as soon as they appear. This allows the plant to vigorously produce early vegetative growth that is essential for maximum fruit production. Fruits above the basal 24-30 inches of the main stem are then allowed to develop. V-cordon trained plants are known as the umbrella system. In this system, all lateral branches are pruned out as they appear until the main stem reaches the overhead wire. The growing point of the main stem is removed when one or two leaves have developed above the wire. Two lateral branches near the top of the plant are allowed to grow and are trained over the overhead wire resulting in these two branches growing downward. The growing point of each lateral is removed when nearly to the ground. Fruits are developed at the node of each leaf. The productivity of the laterals is generally less than the main stem.

Fruit physiological disorder

Crooking: A serious physiological disorder, results in decreased yields and reduced quality of greenhouse cucumbers. Curvature in fruit begins at an early stage—often when the ovary is less than ½ inch long—and remains throughout maturity. Slight curvature (up to 1 inch per 12 inches of fruit length) is tolerable in first-grade fruit, but excessive curving or crooking reduces market value.

Harvesting

Cucumbers are harvested as immature fruit when full length has been reached. At suitable harvest maturity, a jellylike material has started to form in the seed cavity. Cucumber production will be reduced if the fruit are left on the plant for too long. Cucumbers are hand harvested, normally 3 times per week, depending on the weather and growth stage of the plant.

Post-harvest handling

Cucumbers lose moisture quickly and have the tendency to soften during storage. Marketable cucumbers should be sorted according to size and quality and individually wrapped in clear plastic. The optimum storage temperature for cucumbers is 10-12.5°C, at relative humidity of 95% RH. Storage or transit temperatures below this range should be avoided as this will result in chilling injury after 23 days.

Advantages through Advance approaches of protected cultivation in arid region

1. Round the year production of vegetables.
2. Adverse climate for production of vegetables can be overcome by different systems of protected production.
3. Multiple cropping on the same piece of land is possible.
4. Off season production of vegetables to get better return to growers.
5. Production of high quality and healthy seedlings of vegetables for transplanting in open field supporting early crop, strong and resistant crop stands.
6. Use of protected vegetable cultivation can increase production as well as productivity per unit of land, water energy and labour. It supports the production of high quality and clean products.
7. It makes cultivation of vegetables possible in areas where it is not possible in open conditions such as high altitudes deserts.

8. Disease free seed production of costly vegetables becomes easy under protected structures.
9. The potential of polyhouse production technology to meet the demand of producing good nutrition and healthy foods and quality vegetables free from pesticides can be fully exploited.
10. Controlled environmental conditions are used for early raising of nurseries, off-season production of vegetables, seed production and protecting the valuable germplasm.
11. Water and nutrients are the critical inputs whose optimization is essential in arid and semi arid regions. In view of this, the standardization of efficient fertigation technology will improve the water and nutrient use efficiencies increase the production potential of the crops.
12. The emphasis will be laid on the development of multi-strata cropping systems which will ensure income throughout the year as well as increase the cropping intensity and efficient utilization of natural recourses.
13. Arid and semi-arid regions have low incidences of pest and disease, however, with climate change, the incidence of pest and disease are increasing. This warrants development of integrated pest and diseases models using botanical pesticides so that the produce will find a place in global market.

Thurst areas for improvement in protected cultivation

- Identification of new crops /varieties suitable for cultivation inside the green house.
- Large scale motivation and training of educated unemployed youths in the field of protected cultivation
- Standardizing proper design of construction of polyhouse including cost effective and indigenously available cladding and glazing material.
- Computerized Control System, which includes various factors which are as required for the plant to maximize returns.
- Developing cost effective agro-techniques for growing of different vegetable crops in the different types of poly houses and lowering energy costs of the green house environment management.
- Major research activities on growing of vegetables under protected covers should be launched by ICAR and SAU's.

- Import of planting materials, structural designs and production technologies which are not relevant under Indian conditions should be stopped and in turn emphasis should be given to develop own F1 hybrid varieties so that seed are made available to the growers in time and at cheaper rates.
- Government initiatives/efforts in popularizing the greenhouse technology among the farming community of the country are to be strengthened.
- With the increase production of arid fruits and vegetables, the country will not only keep pace with increasing demand of fruits and vegetables but will also be in a position to export the value added products. The programme on successfully completion will also limit the process of degradation of natural resources to promote sustainability by standardization of low input and environmental friendly technologies.

Conclusion

As the population of India is increasing day by day, the demand for quality produce would also increase. But the productivity of vegetables in India is less compared to other leading countries in the world. Besides this, open field cultivation of vegetables causes low yield due to various type of biotic and abiotic stresses. All these necessitate the adoption of new technology which can increase the productivity per unit area along with high input use efficiency. One such technology is protected cultivation which has the potential of round the year production of vegetables with quality produce. Although it is an intensive technology and needs proper care and maintenance but can be very rewarding if adopted on commercial scale by the resourceful farmers near big cities of the country. The maximum return on investment can be achieved through protected cultivation of vegetables because it not only produces high quality yield but also gives higher market price to the growers.

References

- Chakraborty, Hillolmoy and Sethi, Laxmi Narayan 2015. Prospects of Protected Cultivation of Vegetable Crops in North Eastern Hilly Region. *International Journal of Basic and Applied Biology*, 2(5): 284-289.
- Chatterjee Ranjit, Mahanta Sandip And Pal P.K. 2013. Adoption status and field level performance of different protected structures for vegetable production under changing scenario. *The Indian Journal of Agricultural Science*, 1 (1): 11-13.
- Kouser Parveen Wani, Pradeep Kumar Singh, Asima Amin, Faheema Mushtaq and Zahoor Ahmad Dar. 2011. Protected cultivation of tomato, capsicum and cucumber under kashmir valley conditions. *Asian Journal of Science and Technology*, Vol. 1(4); 56-61.
- NAAS (National Academy of Agricultural Science) 2010. "Protected agriculture in North – West Himalayas" Policy paper no.47.
- Nair Reena and Brache Swati 2014. Protected Cultivation of Vegetables: Present Status and Future Prospects in India. *Indian Journal of Applied Research*, 4 (6); 2249-555X.

- Pishfaq Akbar, M S Kanwar, M Saleem Mir, Anwar Hussain 2013. Protected Vegetable Cultivation Technology for Cold Arid Agro-ecosystem of Ladakh. *International Journal of Horticulture*, 3(19): 109-113.
- Singh, D.K. and K.V. Peter 2014. Protected cultivation of Horticultural Crops, published by New India Publishing Agency New Delhi-110034
- Sanwal S.K., Patel K.K. and Yadav D.S. Vegetable production under protected conditions in Leh region : problems and prospects. *ENVIS Bulletin*, 12(2): *Himalayan Ecology*.
- Shweta, Bhatia S.K. Bhatia and Malik Manu 2014. *Protected Farming*, 2(1) pp. 21-25.
- Wani, K. P., Singh, P. K., Amin, A., Mushtaq, F. and Dar Z. A. 2011. Protected cultivation of Tomato, Capsicum and Cucumber under Kashmir Valley Conditions. *Asian Journal of Science and Technology* 1(4): 56-61.
- Yadav ,R.K., Kalia, P., Choudhary, H. and Zakir Husaian and Brihamadev 2014. Low cost polyhouse technologies for higher income and nutritional security. *International Journal of Agriculture and Food Science Technology*, 5(3):191-196.