Year-Round Intensive Organic Vegetable Production under Protected Cultivation

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Introduction

India is the second largest producer of vegetables in the world next to China. Horticulture production is gaining importance in the country and there has been a record production of horticulture crops with production reaching 311.7 Million Tonnes during year 2017-18 which is 3.7% higher than the previous year and10% higher than the past 5 years' average production.The contribution of vegetables remains highest (59–61%) in horticulture crop productions over the last five years. During 2017-18, the area under vegetables is estimated at 10.3 million ha with a production of ~180.0 million tones in India. According to FIBL & IFOAM Year Book 2018, **India rank 9th in terms of World's Organic Agricultural land and 1st in terms of tota l number of producers**. India produced around 1.70 million MT (2017-18) of certified organic products. The total organic produce exported during 2017-18 was **4.58 lakh MT of worth Rs. 3453.48 crore(515.44 million USD)** *(http://apeda.gov.in)*. The total area in India under organic certification is ~5.71 million hectare and total certified organic cultivable land in Sikkim is ~78,000 hectare with an average size holding of 1.17 hectare.*(www.apeda.gov.in)*. The market for organic vegetables is on the increase and there are a variety of markets possibilities for producers who want to grow certified organic vegetable crops. Vegetables are an important source of food and nutrition and provide regular cash income. Vegetables, especially as practiced by smallholder farmers in developing countries are particularly vulnerable to climate change. Adapting vegetable productionto climate change is essential for promoting food security and poverty alleviation, as well as for the sustainable management and conservation of natural resources. Many countries already are experiencing climate change impacts such as irregular, unpredictable rainfall patterns, increased incidence of storms and prolonged droughts. Changing weather patterns also allow for the emergence of pests and diseases that affect crops and animals. Adoption of protected cultivation techniques with organic management not only increases productivity and income but also reduces risks from extreme weather events and climate changes, and also contributes to reduced emission efforts. Protected cultivation or plasticulture in the forms of greenhouses, net houses, low tunnels, mulches etc. offers several advantages to grow crops of high quality and yields, thus using the land and other resources more efficiently. According to World Greenhouse Vegetable Statistics 2019, an estimated world greenhouse vegetable area is 4,96,800 ha *(www.cuestaroble.com)*.

Advantages of protected cultivation

Earlier production

Protected cultivation raises the temperature, which helps plants grow more quickly and mature earlier. Vegetables grown under low cost plastic tunnels, plastic rain shelters or on black plastic mulch can be harvested 7 to 21 days earlier. Harvesting one to two weeks earlier often significantly increases market advantage and the prices growers receive.

Reduced loss of nutrients

Many bio-fertilizers nutrients are not held tightly in the soil and heavy rainfall may leach them below the roots of plants grown on bare ground. Protected cultivation prevents rainfall from percolating through the soil and leaching nutrients beyond reach of plant roots especially in light sandy soils. Preventing leaching improves the efficiency of production and quality of produce.

Weed controls

Black plastic mulch prevents the growth of most weeds thus reducing the labour requirement. Clear plastic, however, does not prevent weed growth because light can penetrate it.

Increased plant growth

Plants grow more under protected conditions because of greenhouse effects and increase in air & soil temperatures. When plants are grown under protected conditions, the CO2 released from plants during night accumulates in the greenhouse and eventually increases the photosynthetic efficiency during day time.

Less water requirement

Mulching helps in reducing evaporation from the soils and maintained soil moisture more uniformly than the open field conditions. Since plant growth rate on mulch may be twice that on unmulched soil, plants may require more water even though evaporation is reduced. Mulching cannot substitute for a sound irrigation program. However, less water evaporates from soil under plastic mulch and therefore less water required for per unit of production.

Improved quality

Vegetables grown under protected conditions are cleaner, disease free and less subject to rots especially during rainy season.

Reduced soil compaction

Soil under plastic low tunnels and mulch remains loose, friable, and well aerated. Roots have access to adequate oxygen, and microbial activity is enhanced.

Disadvantages of protected cultivation

Greater initial costs

Establishment of protected structures requires an intitial investment making production costs significantly higher than for traditional practices. Yearly maintenance costs further increase production expenses. These costs, however, should be offset by increased returns from earlier harvests, better quality and higher yields.

Increased management

Although plasticulture technology offers several important advantages over conventional production practices, it requires skilled and trained persons to harness the full potential of protected cultivation. Timely management of all the operations is necessary to get higher and quality produce.

Preliminary considerations prior to going into protected cultivation

Before deciding to go for the protected cultivation or plasticulture system for high value crops, one should carefully consider the following factors:

- Vegetables intended to grow suits to production under protected cultivation.
- Vegetables should be intensively managed under various cropping systems.
- Sufficient financial resources available or obtainable.
- Good market availability.
- One should establish first a successful track record growing high value crops under open conditions then plasticulture system may be profitable.

General cultivation practices for organic vegetables

Site

Site should be free from gravels, well drained and near to market. Site preparation is an important component of a successful protected cultivation system. The field should be ploughed early and allowed sufficient time todecompose the applied FYM or organic manure before planting crops.

Orientation

A north-to-south orientation is recommended for more uniform plant stands and ripening. However, facilitating soil drainage is the most important factor to be considered for planting.

Soil

Healthy soil is the basis of organic farming. Regular additions of organic matter in the form of cover crops, compost, or manure create a biologically active soil, with good structure and capacity to hold nutrients and water. The practice of crop rotation to promote a healthy soil should be initiated in the one or two years prior to planting establishment. This is best for both reducing soil pests and maintaining soil organic matter.

Land preparation

Land preparation or bed shaping, is an important practice in the protected cultivation system. The soil must be loose and friable and free of stones, clods, sticks, and undecomposed plant residue. About 4-5 inch raised bed should be prepared. The land should be prepared to a fine tilth for low cost plastic tunnels, low cost plastic shelters, low cost plastic greenhouses and open conditions. Well decomposed FYM to be applied @ 1.5-2.0 kg/m2 or vermicompost @ 0.5-1.0 kg/m2 along with neem cake @ 200 g/ m^2 at the time of final land preparation. If soil is acidic in nature, it is advisable to apply dolomite/lime @ 200 g/m2. Lime should be applied at least 20-30 days before planting.

The soil should be prepared well and brought to a fine tilth before transplanting. Green manure crops like dhaincha, sunhemp and cowpea should be cut after 45 days of planting and after chopping in to small pieces can be applied in soil to further improve the nutrient status in soil.

Plastic Tunnel

Green manure crops are capable of accumulating 4-5 t/ha of dry biomass and 100 kg N2/ha in 50-60 days.

Pollination

Pollination should be a major problem under low cost plastic tunnels and low-cost plastic greenhouses so it is advised to grow self pollinated vegetables or leafy vegetables.

Nursery management and sowing methods

Nursery should be raised under protected condition in low cost polyhouse or under low cost plastic tunnels. Seeds of cole crops, pakchoi, rayo sag etc., can be sown in nursery about 30-40 days before transplanting. The selected area should be free from soil-borne diseases, well leveled, fertile and provided with better irrigation and drainage facilities. The raised bed of 15 cm height and 5 m x 1 m size should be prepared. The seeds should be sown in rows made 10-15 cm apart and 1.5 cm deep. Watering should be done regularly to maintain the required moisture for proper germination. The bed should be covered with thin layer of dry grass to check evaporation and to maintain temperature. As soon as the seeds germinate the upper grass layer should be removed carefully and later on cultural operations should be followed as per requirement. Normally four to six weeks after seed sowing the seedlings are ready for transplanting. Irrigation should be stopped one week before transplanting. Cole crop, okra, dalley chilli and tomato seedlings should be treated with Azospirillum + Phosphate Solubilizing Bacteria (PSB) (20 %) for 15 minutes at the time of transplanting to get better yield and quality produce. Transplanting of cole crops seedling is done in rows at a distance of 30 cm x 30 cm. Direct seeding should be done for

leafy, root and other vegetables after seed treatment with Trichoderma viride @ 1g/kg seed to reduce damping off (seedling rot) disease.

Interculture and irrigation

Most of the vegetables like cole crops and leafy vegetables are shallow rooted crop and roots are restricted within 15-20 cm of soil so light earthing up should be done after 30 days and 45 days of planting and deep cultivation should be avoided.Regular shallow cultivation should be given to the soil to remove young weeds and to provide soil mulch. Once the foliage has covered the soil, it is better to stop hoeing since it may damage the roots. Normally three to four hoeing and weddings are required to keep the crop weed free.Vegetables require sufficient moisture in the soil for uniform and continuous growth. Hence, frequent irrigation at 10-15 days interval is given depending on weather conditions for the crops under protected cultivation. The dry conditions adversely affect the quality and yield of shoots by being more fibrous.

Organic vegetable production under low cost protected structures

The Indian scenario has changed tremendously during the last decade because of change in the life style and food habits. The people are becoming more aware to eat healthy foods. High value crops like vegetables are an important component of health food and provide nutritional and health security. Though, the greenhouse technology has registered substantial growth in the recent years on productivity and quality improvement around the globe but still the low cost protected structures are preferred over high cost structures considering the cost involved and poor financial status of Indian farming community. The most common low cost protected structures are:

a. Low cost plastic tunnels

Low cost plastic tunnels or open tunnels are greenhouse-like structures, covering the plants along the row. These tunnels are about 1.0 m high and 1.5 m wide at the base and are erected with bamboo sticks or wooden poles of about 1 inch diameter. A transparent UV stabilized plastic sheet of 35 or 45 GSM is placed on the bamboo structure to allow sunlight during the day passes through the plastic sheet, and is absorbed by the soil.

Walk-in-Tunnel

This raises the temperature to desired levels. The plastic sheet serves two purposes: first it traps heat and reduces water loss and second it protects plants from adverse climatic conditions. Transparent plastic films are stretched over low (about 0.5 m or so) as a flexible wall on both sides of tunnels. The plastic films are properly tied up on bamboo structures with wire. Good cross ventilation and potential stresses caused by heavy wind, hail or heavy rains must be considered while constructing the structure.

Advantages of low-cost plastic tunnels

- Vegetables can be produced year-round regardless of the season to get better return.
- Provides crop diversification opportunities and supports production of high quality and clean products.
- Makes cultivation of vegetables possible in areas where it can't grow in open conditions viz. high altitudes.
- Used for raising healthy and early nursery.
- Maintains optimum temperature for plant growth.
- Enhances nutrients uptake by the plants.
- Increases photosynthetic activities of the plants.
- Used for cultivation during winter.
- Protection against wind, rain, frost and snow.

Vegetable cropping sequences for low cost plastic tunnels

#	Cropping Sequences
1.	Broccoli - Spinach - Coriander - Broccoli - Coriander
2.	Broccoli - Coriander - Cabbage - Radish - Coriander
3.	Coriander - Radish - Fenugreek – Spinach - Coriander
4.	Cabbage - Local Rayo Sag - Broccoli – Coriander
5.	Cabbage - Spinach - Broccoli - Coriander
6.	Coriander – Radish –Fenugreek – Cauliflower - Pakchoi

b. Low cost plastic rain shelters

Plastic rain shelters are very simple structures, covering the plants along the row. These are about 7 ft. high at one end and 6 ft. high at other end to give slanting roof. Crossed bamboo sticks are placed at the roof for supporting the plastic sheets. The width of these shelters can be 6-8 ft. The plastic rain shelters are erected with bamboo or wooden poles of about 1-2 inch diameter.

Bambo Polyhouse

A transparent UV stabilized plastic sheet of 45 GSM is placed on the bamboo structure to cover the roof. The plastic films are properly tied up on bamboo structures with wire. The plastic sheet simply protects the plants from adverse climatic conditions for eg. high rainfall, hail storms and frost during winter.

Advantages of low-cost rain shelters

- Vegetables can be produced in rainy season to get better return per unit area.
- Provides crop diversification opportunities and supports production of high quality and clean produce viz.

tomato, cucumber, gourds, capsicum, pea etc.

- Maintains optimum temperature for plant growth.
- During winter season it protects crop from frost.
- Protection against wind, rain and hail storm during rainy season.

Vegetable cropping sequences for low cost plastic rain shelters

#	Cropping Sequences
1.	Tomato –Tomato - Pea
2.	Bitter gourd/Sponge Gourd/Bottle Gourd –Tomato - Pea
3.	Bitter gourd/Sponge Gourd/Bottle Gourd – Capsicum - Pea

c. Greenhouse

Greenhouses are generally madeup of various clading material viz., polycarbonate sheet, FRP sheet or plastic sheet (low cost polyhouse). The high priced vegetables viz., broccoli, tomato, cucumber and capsicum are most important crops for production during winter season or off-season in greenhouse. Generally indeterminate tomato varieties are grown in the protected structures to utilize vertical space judiciously. Optimum spacing found suitable for tomato is 60 x 60 cm, capsicum is 40 x 40 cm and cucumber 100 x 100 cm. It has been found suitable that tomato should be maintained as single stem plant by regular pinching of auxiliary side branches and train them along the string. Capsicum and cucumber can also be pruned and trained in such fashion. At the stage of first branching, two or more shoots along with crown flower buds develop naturally. This crown bud should be pinched off with side branches to allow one or two branches to develop as main branch and trained along the string. Plant do keep producing the terminal flower buds on the side shoots pruned as main stem, which should be pinched to allow plant to grow continuously. Pruning is done frequently at an interval of 15 days to avoid crowding of branches. In tomato, fruits are harvested at turning to red ripe stage according to the market distance capsicum are harvested at full mature green stage or full ripe (red or yellow) but firm stage as per market demand generally capsicum requires 45 days from anthesis to full grown mature green stage and further about three weeks to reach firm ripe stage.

Tomato in Polyhouse

Advantages of greenhouse

- Vegetables can be produced year-round regardless of the season to get better return.
- Provides crop diversification opportunities and supports production of high quality and clean products.
- Makes cultivation of vegetables possible in areas where it can't grow in open conditions viz. high altitudes.
- Maintains optimum temperature for plant growth.
- Used for cultivation during winter.
- Protection against wind, rain, frost and snow.

Vegetable cropping sequences for low cost polyhouse

#	Cropping Sequences
1.	Cucumber –Tomato – Cabbage (Cole Crops)
2.	Capsicum –Tomato – Broccoli (Cole Crops)
3.	Tomato – Capsicum – Cauliflower (Cole Crops)

Major challenges in organic vegetable production

- Sustain production under the changing climatic conditions and increased competition for land, labour, water and energy for other economic uses.
- Breed/identify crop varieties for organic production system.
- Develop efficient and cost-effective seed and planting material supply chain to augment productivity.
- Develop cost effective production technologies.
- Ignorance of right stage of harvesting and value addition which results in low price of produce.
- Inadequate attention towards value chain management to prevent losses and to ensure supply during off seasons.
- Creation of value chain infrastructure and establish market information system for intelligent marketing of truthfully labeled produce to fetch better price.

Strategies for sustainable development

- Horticulture advisory service needs to be strengthened.
- Awareness should be created for off-season vegetable production on scientific lines.
- Protected crop and nursery production technology should be popularized to make it profitable/viable on commercial scale.
- Infrastructure for post-harvest management viz., cool transport chain, pre-cooling units, packing houses, short- and long-term cold stores etc. should be developed.
- Human Resource Development programmes should be strengthened with higher emphasis on training of farmers for scientific cultivation of vegetable crops.
- Extension network for dissemination of knowledge/technologies and monitoring of their adoption should be strengthened.
- Agri Export Zone should be identified by the Government for export of organic vegetables and contract cultivation / cooperative farming should be encouraged.