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Deepak Kumar
Department of Agriculture, Moradabad, Uttar Pradesh, India

Satendra Kumar
S.V.P. University of Agriculture & Technology, Uttar Pradesh, India

Corresponding Author:
Deepak Kumar
Department of Agriculture, Moradabad, Uttar Pradesh, India

Vegetables cultivation under the protected conditions

Deepak Kumar and Satendra Kumar

Abstract
Vegetables cultivation in open fields is increasingly limited by weather extremes and water shortages, in addition to insect-pests and different soil-borne diseases. Consequently more pesticides are being used for protecting the crops which deteriorate the vegetable quality by the presence of residues. In order to increase productivity, fruit quality as well as quality yield and protected cultivation can play an important role as an alternative and supplemental production system to conventional open field production. In addition, the biotic stresses also do not allow successful production of vegetables like capsicum, cucumber, tomato, hot pepper, okra/ladies finger, cauliflower, cabbage, leafy vegetables etc. in the fields mainly during rainy and winter season. In spite of the great importance of vegetable crops, it faces a lot of restraints like temperature stress, photostress, moisture stress and weeds growth, nutrients deficiency in the soil, excessive wind velocity and atmospheric CO_2. Different protected cultivation structures having different temperature, humidity, UV radiation ranges and also having different cost involvement in construction of structure which may results the production of vegetables with distinct advantage of good quality fruits, productivity and favorable market price to the growers/farmers. Intense heat and high incidence of UV rays in dry months reduce the quality of leafy vegetables in open which otherwise very good in protected structures. Protected cultivation has great scope to achieve self-sufficiency in vegetable sector even with less area. These structures are constructed using a UV stabilized agro-shade net (35–70% shade) materials for creating partial shade condition inside the structure to favour the growth and development of partial shade requiring crops or to protect crop from scorching heat during hot/summer months. The partial shade effect helps in fast and better growth of leafy vegetables besides reducing the evapo-transpiration loss of water. Low cost shade net for high value leafy vegetables like coriander, lettuce, spinach, chenopodium, fenugreek, amaranth, mustard green etc. This also creates environmental concern as the limited soil and fresh water bodies are get contaminated. The net house/poly house can be used for year round cultivation of crops such as capsicum, tomato, okra, cauliflower, cabbage, brinjal, beans, parthenocarpic cucumber and other cucurbits with reduced incidence of insect-pest and diseases and consequent low chemical residues on the produces. The cost can be reduced drastically by the use of local wood materials like bamboo/wooden poles. Vegetable growers can substantially increase their income by protected cultivation of vegetables in off-season as the vegetables produced during their normal season generally do not fetch good returns due to large availability of these vegetable in the markets. Protected cultivation enables us to grow vegetables in the off-season and also to extend the vegetable growing seasons for a much longer period than is possible under open field conditions.

Keywords: Protected conditions, vegetable cultivation, shade net/green houses types and benefits

Introduction
India is the second largest producer of vegetable crops in the world next only to China. However, its vegetable production is much less than the requirement if balanced diet is provided to every individual. There are different ways and means to achieve this target, e.g., bringing additional area under vegetable crops using hybrid seeds, use of improved agro-techniques and another potential approach is perfection and promotion of protected cultivation of vegetables. Vegetables are recognized as health food globally and play important role in overcoming micronutrient deficiencies and providing opportunities of higher farm income. The worldwide production of vegetables has tremendously gone up during the last two decades and the value of global trade in vegetables now exceeds that of cereals. The worldwide production of vegetables has doubled over the past quarter century and the value of global trade in vegetables now exceeds that of cereals. Vegetables are generally sensitive to environmental extremes, and thus high temperatures and limited soil moisture are the major causes of low yields and will be further magnified by climate change. India has witnessed increase in horticulture production over the last few years. Significant progress has been made in area expansion resulting in higher production. Over the last decade, the area under horticulture grew by 2.6% per annum and annual production increased by 4.8%.

During 2017-18, production of horticulture crops was 311.71 M.T. from an area of 25.43 M.H. (*Horticultural Statistics at a Glance 2018*). The production of vegetables has increased from 101.2 M.T. to 184.40 M.T. since 2004-05 to 2017-18. It is the second-largest producer of vegetable producer, accounting for 8.6% of the world vegetable production (according to FAO). In natural season local vegetables flood the markets substantially bringing down the prices. In the absence of storage infrastructure and vegetable processing industry in the country, off-season vegetables farming is the only viable option that can add value to the farmer produce. Vegetables can be cultivated in off-season, with the induction of an artificial technique like greenhouse technology, in which temperature and moisture is controlled for specific growth of vegetables.

Protected cultivation

Protected cultivation practices can be defined as a cropping technique wherein the micro environment surrounding the plant body is controlled partially/ fully as per plant need during their period of growth to maximize the yield and resource saving. Greenhouse is the most practical method of achieving the objectives of protected agriculture, where natural environment is modified by the use of sound engineering principles to achieve optimum plant growth and yield with increased input use efficiency. Protected cultivation of vegetables offers distinct advantages of quality, productivity and favourable market price to the growers. Vegetable growers can substantially increase their income by protected cultivation of vegetables in off-season as the vegetables produced during their normal season generally do not fetch good returns due to large availability of these vegetable in the markets. Off-season cultivation of cucurbits under low plastic tunnels is one of the most profitable technologies under northern plains of India. Walk-in tunnels are also suitable and effective to raise off-season nursery and off-season vegetable cultivation due to their low initial cost. Insect proof net houses/green houses can be used for virus-free cultivation of tomato, hot pepper, capsicum, cucumber, leafy vegetables and other vegetables mainly during the rainy season. These low cost structures are also suitable for growing chemicals-free green vegetables. The green house is generally covered by transparent or translucent material such as glass or plastic. The green house covered with simple plastic sheet is termed as poly house. The sunlight admitted to the protected environment is absorbed by the crops, floor, and other objects. These objects in turn emit long wave thermal radiation in the infra red region for which the glazing material has lower transparency. As a result the solar energy remains trapped in the protected environment, thus raising its temperature. New features added to these structures have cut down the requirement of water and energy in such cultivation through novel means like micro irrigation-cum-fertilization and rainwater harvesting. The gardeners planted cucumbers in carts that were wheeled into the sunlight by day and brought indoors by night to protect them from the elements. At present nearly 90 per cent of the new greenhouses are being constructed by utilizing ultra violet (UV) stabilized polythene sheets as the glazing material. There are more than 55 countries now in the world where cultivation of crops is undertaken on a commercial scale under cover and it is continuously growing at a fast rate internationally. China is the largest users of greenhouses.

Protected cultivation on commercial scale is undertaken in over 50 countries over the globe. First modern greenhouses were built in Italy in thirteenth century. In India green house technology started in 1980 and initially it was used for research only. In India first polyhouse was designed and set up in 1985 at Leh (Laddak). The development of greenhouse technology in China has been faster than in any other country in the world. With a modest beginning in late seventies, the area under greenhouses in China has increased tremendously. The world scenario of greenhouse production is given in Table-1.

Table 1: Area under greenhouse(s) in different Countries

Sr. No.	Countries	Greenhouse area (Ha)
1	China	2,760,000
2	South Korea	57,444
3	Spain	52,170
4	Japan	49,049
5	Turkey	33,515
6	Italy	26,500
7	Israel	18000
8	Mexico	11,759
9	Netherlands	10370
10	France	9,620
11	United states	8425
12	India	5730

Source: Kacira (2011) [6]

India's first exposure to truly hi-tech protected farming of vegetables and other high-value horticultural produce came through the Indo-Israel project on greenhouse cultivation, initiated at the New Delhi-based Indian Agricultural Research Institute (IARI) in 1998, shortly after the establishment of diplomatic ties with that country. However, the Israeli experts left India in 2003 at the end of this five-year project, IARI continued to maintain the facility, calling it the Centre for Protected Cultivation Technology. It has, in the past 10 years, managed to refine and upscale the system to reduce costs, besides designing greenhouse structures to suit local conditions. During last decade this area must have increased by 10 per cent if not more. The states that have consistently expanded the area under protected cultivation for the period of 2007-2012 are Andhra Pradesh, Gujarat, Maharashtra, Haryana, Punjab, Tamil Nadu and West Bengal. Maharashtra and Gujarat had a cumulative area of 5,730.23 hectares and 4,720.72 hectares respectively under the protected cultivation till 2012. In Europe, Spain is leading in protected agriculture with 51,000 ha mostly under low cost poly houses. In Asia, China has the largest area under protected cultivation, 2.5 million ha under poly house/greenhouse. Protected vegetable

production is important component of protected agriculture. Protected vegetable production is practiced throughout the world irrespective of altitude of the place since several hundred years.

Cucumber Cultivation under Net House

Benefits of protected vegetable

- Conserve the soil moisture
- Income in the off-season increased by 48%, but pesticide use also increased by 56%
- Adverse climate for production of vegetables can be control by different systems of protected production
- We assess the impact of training in off-season cultivation and production of vegetables to get better return to growers
- Safe pest management needs emphasis to avoid adverse health outcomes
- Vegetable crops can be grown under adverse weather conditions round the year
- Multiple cropping on the same piece of land is possible
- Production of high quality and healthy seedlings of vegetables for transplanting in open field supporting early crop, strong and resistant crop stands
- Use of protected vegetable cultivation can increase production as well as productivity per unit of land, water, energy and labour.
- It makes cultivation of vegetables possible in areas where it is not possible in open conditions such as high altitudes deserts
- Disease free seed production of costly vegetables becomes easy under protected structures
- 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
- Controlled environmental conditions are used for early raising of nurseries, off-season production of vegetables, there seed production and protecting the valuable germplasm
- Management and control of insect-pests, diseases and weeds is easier

Maintenance of plants

- Hand pollination in cross pollinated vegetables like cucurbits or development of their parthenocarpic cucumber
- Costly, short life and non-availability of cladding materials.
- Lack of appropriate tools and machinery.
- Structure cost initially looks unaffordable. Farmers with zero risk affordability do not come forward to adopt it.

Climate Control

- Maintain humidity 60-80%
- Maintain optimum temperature 18-24^0 C
- Ensure sufficient air circulation around the plants
- Ensure carbon dioxide concentration >300ppm

Strategies

- Increase the awareness of the farmers of international standards and technology transfer in the field of Integrated Crop Management (ICM), Integrated Pest Management (IPM) and Good Agricultural Practices.
- Stimulate the production of non-traditional crops (cauliflower, paprika, leek, carrots and lettuce) and other production methods (organic crops).
- Increase the acreage with vegetables for prioritized vegetables (long bean, okra, hot pepper, eggplant, tannia leaves, bitter gourd), the precise crops to be determined after a detailed market survey.
- Create a board for all stakeholders in vegetables production and marketing

Types of green houses

1. Low cost or naturally ventilated polyhouse
2. Plastic greenhouses with natural ventilation
3. Solar greenhouses
4. Plastic low tunnels
5. Walk-in tunnels (Dry temperate areas)
6. Net houses and Anti-insect cages
7. Underground trenches (Leh and Ladakh region)
8. Plastic mulches

Location of Green House

1. Solar Radiation: The greenhouse should be located where it gets maximum sunlight. The first choice of location is the south or southeast side of a building or shade trees. Sunlight all day is best, but morning sunlight on the east side is sufficient for plants. Morning sunlight is most desirable because it allows the plant's food production process to begin early; thus growth is maximized. The next best sites are southwest and west of major structures, where plants receive sunlight later in the day.

2. Water: Water quantity and quality is crucial. Water will be needed for the evaporative cooling system and can equal or exceed the irrigation water amounts. In the past, excess irrigation and bleed-off water from the evaporative cooling system was allowed to "run off" onto the ground adjacent to the greenhouse. However, due to more strict regulations and a desire to avoid ground water contamination with high concentrations of salts, large greenhouses are now recirculating the nutrient solution.

3. Elevation: It will affect the summer maximum and the winter minimum temperatures. Choosing an appropriate elevation will minimize heating costs in the winter and cooling costs in the summer.

4. Microclimate

- **Large bodies of water:** Will tend to moderate the temperature (e.g., coastal areas tend to have smaller day/night temperature differences than inland areas).

- **High Wind Areas:** High winds can "suck" heat away from the greenhouse and therefore increase the heating energy needed to maintain the temperature inside. High winds can also cause structural damage to greenhouses.
- **Latitude:** Unless the global climate changes drastically, sea level at the poles will be colder than sea level in the tropics. Hence, latitude makes a difference!
- **Snow:** The weight of heavy, wet snow on a greenhouse could crush it. However, high winds in snow areas can also blow snow up against the greenhouse structure (snow drifts) and cause damage to it. This danger can be reduced by using windbreaks (trees, snow fences, etc.).

5. Roads- Need access to good roads to transport the product. Good roads close to a large population center or to a brokerage center aids wholesale and retail marketing.

6. Availability of Labour: The grower needs people who will want to work as labourers and who are "trainable" to become a retainable workforce. Such skills included training/pruning the plants and harvesting/packing the fruit. Special labour will include people with additional training in such fields as plant production, plant nutrition, plant protection (insects and diseases) computers, labour management, marketing, etc

7. Management residence: The grower/manager residences should be close to the greenhouse so that they can get to the greenhouse quickly in case of emergencies.

8. Community profile: Prior to selecting a site for greenhouse construction the grower should obtain a community profile for potential locations. These are available at the city or area Chamber of Commerce and contain Community background information:

- Location, elevation, history and weather
- Population, employment structure and labour force information
- Growth indicators, principal economic activities and property tax information
- Available properties, financing, transportation, communications and utilities
- Government, medical and educational services

Causes for damage of green house: The main factors are:

a. The profile used in the GH frame, trusses and other member too light which deformed
b. Strong Winds
c. Cladding material some time appeared to be stronger than structure
d. Poly film tearing because of rough and sharp edge of the frame
e. The foundation not sufficiently secured against uplift forces

Conclusion

The greenhouse technology is still in its preliminary stage in India and concerted efforts are required from all concerned agencies to bring it at par with the global standards. Economically viable and technologically feasible greenhouse technology suitable for the Indian agro-climatic and geographical conditions is needed at the earliest. Globalization coupled with economic liberalization will help in achieving the desired results. Efforts should be made to synthesize energy conservation principle along with environmental safety on a broader perspective. The future needs for improving this technology are:

- Standardizing proper design of construction of polyhouses including cost effective and indigenously available cladding and glazing material.
- Developing cost effective agro-techniques for growing of different vegetable crops in the different types of polyhouses and lowering energy costs of the green house environment management.
- Computerized Control System maximize returns it includes time base/volume base/sensor based irrigation system, opening and closing of ventilators and side wall roll up curtains, CO2 generator, climate control, temperature, tumidity, heat radiation, control of EC, pH, ppm level of elements in irrigation water etc. as required to the plant.
- 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.

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