Review Article

A Review-Protected Cultivation of Vegetables: Opportunities and Challenges

Abstract

Protected farming techniques are set of agricultural ~~practices that is~~practices that are designed to produce a plant in a controlled environmental condition by using soil cover and / or crop covers to control pests and effect of climate. While a protected farming method can increase the productivity of vegetable crops as well as growth and yield. It is evident that protected farming has been found beneficial for farmers. In addition to its great importance, it challenges many biotic and abiotic factors such as photo-stress, water stress, heat stress, weed growth, soil nutrient deficiencies, high wind velocities and atmospheric carbon dioxide, pest and diseases. The various benefits of a protected vegetable crop are quality, profitability, and a good level of marketing for farmers. Protected cultivation is an imminent technique for raising vegetables, flowers and other high rated as well as consumable crops. In advance agriculture, protected structures held an excessive potential for more production with greater productivity. The chapter contains the status, challenges and opportunities of protected cultivation and related government schemes for horticultural plants in India especially Uttar Pradesh. It has been found that the cumulative area has been acquired under NHM-protected cultivation in India. Financial support or funding is also provided by the government agency to spread this methodology throughout the country. Recourses are used wisely in these structures because modern methods/techniques were applied.

Keywords: Greenhouse, Biotic S~~s~~tress, P~~p~~rotected ~~c~~Cultivation, Exotic V~~v~~egetables ~~etc~~.

Introduction

India is one of the largest producers of vegetable crops ranks second in the world. Protected cultivation is one of the best and efficient way of raising seasonal and off-seasonal crops under a controlled environmental condition by applying scientific approach. Vegetable and flower crops offer a great deal of potential to create jobs, use land productively, and earn foreign currency through boosting export. Protected cultivation can help in the reduction of greenhouse gas emissions and the overall environmental impact by reducing the environmental hazard and by uplifting food production (Gruda *~~et.~~ a~~A~~l.*, 2019).Vegetables are a highly common and indispensable part of a healthy diet, which is widely recognised for the enormous importance it plays in human nutrition. Over the past 20 years, there has been an abundant increase in worldwide vegetable production, and the value of the global vegetable trade has surpassed that of grains. About 11.2% of the world's total vegetable production, including melons, is produced in India. India is the world's top producer of various vegetables. With an average yield of 18.4 tonnes/ hectare, vegetable production increased from 101.25 million tonnes in 2004–05 to 185.88 tonnes in 2015–16. According to estimates, total horticulture production will reach 341.63 million tonnes in 2021–22, up roughly 7.03 million tonnes (or 2.10%) from 2020–21. Release of the Second Advance Estimates of the Area and Production of Horticultural Crops (2021–2022).

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Potatoes, tomatoes, onions, brinjal, cabbage, cauliflower, peas, okra, chilies, beans, and others are the main vegetable crops grown in India. With 15.9% of the nation's total production of vegetables, West Bengal leads the way, followed by Uttar Pradesh with 14.9%. Other significant vegetable-producing states include Madhya Pradesh (9.6%), Bihar (9.0%), Gujarat (6.8%), Maharashtra (6.1%), Odisha (4.6%), Haryana (3.9%), Andhra Pradesh (3.8%), and Karnataka (3.8%).

Fig 1: Plastic M~~m~~ulching

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Potatoes contributes 28.5% of all vegetables farmed in the nation, followed by onions (12.6%), tomatoes (10.4%), brinjal (6.8%), cauliflower (4.9%), cabbage (4.9%), okra (3.3%), and peas (2.9%) respectively. The development of hybrid vegetables in protected cultivation under MIDH is receiving significant attention in India.

The Indo-Israel project on greenhouse cultivation, which was started at the Indian Agricultural Research Institute (IARI) in New Delhi in year 1998, shortly after the two ~~nations diplomatic relations were~~nation's diplomatic relations were established. It was India's first introduction to high-tech vegetable farming and other high-value horticultural products with international collaborations. The Centre for Protected Cultivation Technology was maintained by IARI after Israeli scientists left India in 2003, when the five-year initiative came to an end (CPCT). Without needing to create temperature-sensitive buildings, it has been possible to increase and develop the system over the previous ten years in order to lower costs. 110 hectares were estimated to be under cultivation in India and over 275,000 hectares were believed to be under cultivation worldwide in the late 20th century (Mishra *et al*., 2010).The results of related study showed that the government schemes, such as subsidies, has to provide to boost maximum farmers to adopt protected cultivation, and finance and marketing support has to be extended to aid in better quality input supply and to realize maximum earnings for farm produce (Kumar *et. a~~A~~l*, 2021).

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Despite all of these accomplishments, per capita consumption of vegetables is still regarded as a nutritious diet worldwide, plays a significant role in addressing vitamin shortages, and generates high farm income. Vegetable production has increased by two-fold over the past two to three decades, and the value of the worldwide vegetable trade has surpassed that of grains. Vegetables are often vulnerable to environmental stress, and climate change will exacerbate low yields caused by high temperatures and limited soil moisture. As the environment is controlled

and inputs like fertiliser, insecticides, and water are used more effectively than they are in open techniques of farming, protected horticulture is more environmentally friendly.

Protected farming is a specialised technology that can be used to lessen these difficulties. The goal is to grow plants in harsh environments because they cannot survive in their natural habitat. Farmers can benefit from favourable quality, production, and price advantages from protected vegetable farming. Compared to the normal season, it boosts their revenues during the off-season. One of the most profitable technologies in India's Northern Plains is off-seasonal farming. Tomato, chilli, sweet pepper, cucumber, and other crops can be successfully grown without viruses or diseases, especially during the wet season.

What is Pprotected Ccultivation/Ffarming?

Plants can be grown in a controlled environment using a popular technique called protected cultivation. Since the Roman era, this method of cropping in a controlled structure has become successful and gain popularity. The Roman gardeners cultivated vegetables for daily consumption using artificial ways (akin to the protected system) (Janick *et al*., 2007). In the 17th century, the idea of protected constructions was also demonstrated in the Netherlands and England. The provision of an acceptable and balanced temperature in these protected buildings was severely constrained. The Netherlands currently has some of the largest playhouses in the ~~world,~~world; some of them are so large that they can produce a lot of vegetable crops each year (Muijzenberg and Erwin, 1980). Due of the high value crops that are farmed in these establishments, protected farming is highly well known throughout the world.

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Fig 2: Tomato in Ssoilless Mmedia

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Protective farming techniques are cropping methods that manage the microclimate around the plant body partially or totally depending on the needs of the kind of plants grown at the time. Depending on the local climate, several farming strategies for protection have been employed. The greenhouse or polyhouse, among them, is especially helpful for year-round vegetable cultivation in temperate regions (Mishra et al., 2010). Protected agriculture, sometimes referred to as controlled environment agriculture (CEA), is extremely productive and sustainable for the preservation of water, land, and the environment (Jensen, 2002). In India, protected agricultural technologies first appeared in the 1990s.

Scenario of protected structures

Throughout 115 nations around the world, use greenhouses to cultivate vegetables. According to the worldwide scenario, there are roughly 623.30 thousand hectares under protected agriculture, compared to the world's total gross vegetable output area of 402.98 thousand hectares. According to Punera *et al*. (2017), the National Horticulture Mission's protected cultivation programme was reported to have about 1.5 lakh acres of land in Himachal Pradesh, India, in the 2014–15 growing season. According to Sabir and Singh (2013), there were around 25,000 ha of protected farming in India in 2012–13, compared to 2000 ha for greenhouse vegetables. According to Kumar *et al*. (2018), the overall number of polyhouses in Haryana increased from 1356 to 1589.

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Why Ddo yYou Rrecommend Ppprotected Ffarming?

The conventional method of growing vegetables is hampered by a number of factors, including significant insect infestation (Nguyen et al., 2009), diseases, storms, temperatures, and humidity that are over the plant nutrition optimum. The most important aspect in horticulture is nature (Trivedi and Singh, 2015). Using protected agriculture, environmental impact can be managed. Producing vegetables continuously in controlled weather is known as protected farming. In addition, vegetables grown outside of protected agriculture generate vegetables of outstanding quality in terms of morphology, including form, size, and colour. The microclimate inside the polyhouse can be altered. Certain insects require UV light to see, and UV opaque poly coating prevents insect from entering the house.

However, the study's findings demonstrated the need for incentive programmes, such as subsidies, to encourage as many farmers as possible to adopt protected cultivation. Additionally, financial and marketing support must be increased to support the supply of higher-quality inputs and to realise the highest possible prices for farm products, compared to the Netherlands, Turkey, and Israel, protected cultivation in India is still in its infancy, with only a 0.2 percent penetration rate. In India, shielded cultivation technique first appeared in the early 1990s. The development of cut flowers with an export focus was made possible by the liberalisation of industry and trade policies. The programmes and incentives of the federal and state governments have consequently resulted in a significant rise.

Fig 3: Seedlings rRaising Uunder Hhi-Ttech Ppoly Hhouse

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Promotional pProgrammes for Ppprotected cCultivation in India

1. National Horticulture Board

The Board is enforcing the schemes are as under:

(A) Development of Commercial Horticulture through Protected Cultivation:

With respect to protected cultivation projects larger than 2500 square meters, the Board offers a credit-linked back-ended subsidy at 50% of the total project costs, up to a maximum of Rs. 56 lakh per project.

(B) Mission for Integrated Development of Horticulture (MIDH)

The National Horticulture Mission (NHM), Horticulture Mission of the North East and Himalayan States (HMNEH), National Bamboo Mission (NBM), National Horticulture Board (NHB), Coconut Development Board (CDB), and the Central Institute for Horticulture are just a few of the programmes that are funded through the Government of India's MIDH initiative, which was launched in 2014–15. These programmes weren't interacting with each other through schemes until lately. However, as of 2014, all of these programmes fell under the same policy's sub-systems, the Mission for Integrated Development of Horticulture (MIDH).

2. National Horticultural Mission (NHM)

NHM is a significant programme that allocates funding in the form of grants with the goal of strengthening the nation's horticulture industry and making it more profitable to farmers. The programme has offered 50% subsidies for constructions of protected structure building and 50% subsidies for the procurement of planting supplies and vegetable cultivation in polyhouses or shade net houses. The area achieved under protected cultivation structure by NHM has been furnished in Table 1.

Table 1. The Aarea aAchieved uUnder pProtected cCultivation sStructure by NHM

Protected Ccultivation	**Total Aarea(ha)**	**Percent Sshare**
Greenhouse structure (fan and pad system)	298.62	0.14
Naturally ventilated polyhouse	4136.81	1.92
Shade net house	4827.5	2.24
Plastic tunnel	4868.35	2.26
Walk-in tunnel	3.84	0.00
Anti-bird / anti-hail nets	6999.99	3.24
High-value vegetable's planting materials grown in poly house	1527.96	0.71
Planting material for flowers for polyhouse or shade net	1674.55	0.78
Plastic mulching	191472.4	88.72
Total	**215809.97**	**100**

[Source: National Horticultural Mission (2005-06 to 2017-18)]

Table 1's analysis revealed that plastic mulching (191472.4ha) was the most common type of farming protection, followed by anti-bird/anti-hail nets (6999.99ha), plastic tunnel (4868.35 ha), shade net house (4827.5 ha), and naturally ventilated polyhouse (4136.81ha). The estimated total area under protected cultivation by NHM from 2005–06 to 2017–18 was 219049.59ha, of which 88.72% was mulched with plastic and 3.24% was covered with anti–bird/anti–hail nets (Prakash *et al*., 2019).

Vegetables ~~s~~Suitable for P~~p~~rotected C~~c~~ultivation

Growing vegetables is more common than growing other crops in many homes. Vegetables have a shorter life cycle and require less area to develop, which accounts for this. Additionally, the plant diversity and crop intensity are better with vegetable crops. In order to combat biotic and abiotic influences and breach the seasonal production barrier, the cultivation of vegetables in polyhouses arises as a distinctive production technology. Additionally, it guarantees year-round production of high-quality veggies, particularly during the off-season, like capsicum (Murthy *et al*., 2009).

According to Cheema *et al*. (2004), a polyhouse improved microclimate is the primary reason for the great output of a range of vegetable crops grown there. Compared to open field circumstances, crop longevity has increased with protected technologies. In comparison to open field settings, poly huts produced the most fruit weight and yield. The net return for various protected technologies was higher with B: C in a poly home and the lowest in an open field (Singh *et al*., 2011).

Favourable weather should be associated with agricultural growth, but the climate nowadays is different. Crop production and profitability are negatively impacted by a harsh climate, such as high temperatures and cold waves. Due to their high sensitivity to climate conditions, it is particularly challenging to cultivate vegetables in open fields throughout the winter in northern India. In northern India, it is highly challenging to grow vegetables in the open during the summer and winter; however, a variety of shielded structures are created to continually grow crops of high value by fostering favourable environmental conditions and offering protection from excessive heat and cold.

The yield and its components of the capsicum plant cultivated in a poly house with natural ventilation are four times more than those produced in the open environment. Compared to cauliflower produced in the field, cauliflower cultivated in polycultures had a shorter period for curd development (Nagalakshmi *et al*., 2001). The farmer uses a variety of market channels to market and sell the tomato products of poly homes. In the Channel Distant market, consumers' rupees made up the smallest percentage. The producer to consumer marketing channel was shown to be the most efficient of all the marketing channels (Bhatia *et al*., 2017).

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Fig 4: Coloured Cc~~c~~apsicum Uu~~u~~nder Pp~~p~~rotected Ss~~s~~tructure

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In polyhouses, capsicum is also growing to a significant level. Due to the cost of the structures, growing capsicum in a polyhouse had a greater overall cost than growing it on an open field, but the net return was better in case of protected cultivation. Capsicum planting beneath polyhouses significantly affects yield (Kumar *et al*., 2016). According to Bhatnagar *et al*.~~(~~. (1990), the yield of capsicum grown under greenhouse conditions increased to 50 quintals per hectare during the winter in the mountainous region of Uttar Pradesh from 24 quintals per hectare when grown under open conditions. Greenhouse plantings produced 2.34 times more capsicum per square metre of land than open fields. After harvesting capsicum, the yield is sold in the market. The farmer receives the highest share of the consumer's rupee from direct capsicum marketing. While a small proportion of consumers interest was seen in distant marketing. By concerning the effectiveness of marketing, producer to direct consumer channel was found most efficient (Bishnoi *et al*., 2017).

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Similar to this, it cost more per hectare to grow cucumbers in a polyhouse than in an open field. Production and net return per hectare in polyhouses were high. With aid of polyhouse technology for growing cucumbers, growers yield and income can be ~~boosted(~~boosted (Kumar *et al*.~~,2~~, 2017). The B: C ratio is higher while growing cucumbers within a greenhouse (Malik, 2017). Cucumbers are grown in Kerala in inexpensive polyhouses with natural ventilation. The highest B~~:C~~: C ratio (3.42) was found when the cucumber received nutrients at a rate equal to 100% of the advised dose (Chand, 2014). Three crop cycles were primarily used in this protected cultivation: tomato-cucumber, capsicum-cucumber, and cucumber-cucumber-cucumber rotation.

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In this case, more cost of cultivation was found in cucumber-cucumber-cucumber while less is found in the capsicum-cucumber under the poly houses. Gross return was highest in crop rotation cucumber-cucumber-cucumber followed by tomato-cucumber and capsicum-cucumber, respectively while net return was higher in cucumber-cucumber-cucumber (Kumar *et al*., 2017). Under polyhouse conditions, production of tomato and brinjal seedlings were respectively 38% and 32% higher and seedlings were ready for transplanting 10-12 days before compared to open conditions. When low-cost polyhouses tested for two crops: capsicum-tomato-lettuce and tomato-French bean-cabbage, the B: C ratio observed were 2.1 and 1.7 respectively (Bhatnagar, 2014).

Fig 5: Insect Pproof Nnet hHouse

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Benefits of Pprotected Vvegetable fFarming

Safe vegetable production can minimize the amount of water and chemicals used in the production of high value vegetables compared to open areas. The relative benefits are:

1. Round the year vegetable production.
2. Opposing climate for vegetable production can be overcome by a variety of protected production systems and availability of desired vegetables throughout year.
3. At the same time on one land area different cropping performance available.
4. Off-season vegetable production for better return to farmers.
5. Production of high quality and healthy vegetable seedlings to be planted in an open field that supports early harvest, strong and resistance crop stand.
6. The use of protected vegetable farming can increase productivity and production per unit of land, water, energy and labour. It supports the production of high quality and clean products.
7. It makes vegetable cultivation possible in areas where it is not possible in open areas such as high-altitude deserts.
8. It enables vertical vegetable planting using technologies such as hydroponics, aeroponics etc and the use of vertical beds for production.
9. Production of disease-free vegetable seeds is easier under protected structures.
10. The potential of polyhouse production technology to meet the need to produce nutritious and healthy food and quality vegetables without pesticides can be fully utilized.
11. Controlled environmental conditions are used for early nursery raising, off-season vegetable production, seed production and protection of valuable germplasm.
12. Vegetable crops can be grown under adverse climate conditions year-round and off season.
13. The control of pests, diseases and weeds is easy to perform under protected cultivation.
14. Maintenance of stock plants, cultivating grafted plantlets and micro propagated plants.

Constraint in Pprotected Cultivation

Protected cultivation can be a key for sustainable crop production in controlled environmental conditions to accomplish food security in the regions confronting the issues of food scarcity and unsuitable weather conditions for various crops. It gives assured crop production and also increases the overall productivity. But the higher initial cost is one the major problem in the adoption of this technology by the farmers (Jadhav and Rosentrater 2017).

Protected cultivation is booming technology for raised vegetables, flowers, and others high valued crops but some constraint is also faced by the farmers. A short life of polysheet and infestation of insect-pest are the major production constraints, whereas high price fluctuations and lack of market information and direct reach to consumers were the major constraints (Kumar *et al*., 2016).

Farmers also face problems related to increasing population of minute insects like mites & whiteflies and frequent occurrence of windstorms, hailstorms, lack of cold storage facilities in villages and problem of nematode infestation were the foremost serious problem faced by the poly house growers (Ghanghas *et al*., 2018).

Lack of awareness among farmers relating to potentials of protected vegetable production and lack of significant research programme on protected vegetable farming are other limiting factors.

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Challenges or limitations

1. Manual or hand pollination in cross pollinated vegetables such as cucurbits or development of parthenocarpic hybrids or varities.
2. Expensive, short life and unavailability of cladding materials.
3. Lack of proper tools and equipment.
4. The initial cost of construction seems inexpensive. Farmers with zero risk affordability do not come forward to involve. (Nair and Barche 2014)

Opportunities

India's long growing seasons, diverse soils and climates that include several natural regions provide ample opportunity to grow a wide variety of vegetables. A great opportunity lies in promoting protected cultivation, as it not only provides better benefits, but also brings pride in the profession and can attract young people including women. Currently, only 50,000 hectares are under protected cultivation in India, and China has 2 million hectares. There is a need for four-fold increase in area (2~~,00,000~~, 00,000 ha) under protected farming over the next 4-5 years. Production under protected conditions not only provides maximum water and nutrient utilization but can also easily increase production by 3-5 folds over open field planting. Use of plastic mulch (25 percent more yield than non-mulched), crop cover or low tunnels (for early crop and low temperature protection), walk-in-tunnels (for temperate region off season vegetables), naturally ventilated polyhouses (tomato, cucumber, flowers), net houses (large number of vegetables and ornamental plant nurseries), environmentally controlled greenhouse (healthy seedlings and leafy vegetables, vertical farming of lettuce, strawberry, etc.), soil less farming (hydroponics, aeroponics, e.g. production of lettuce and potato seeds, vegetable aquaponics), and vegetable grafting, are some of the most important technical interventions that need to be promoted and widely accepted.

Conclusions

There are many programs at both at central and state levels to promote and enhance protected cultivation. The major scheme was NHM which provided a 50 per cent subsidy for the construction of protected structures. The possibilities offered by this technology, namely, the trellising of indeterminate climbing cultivars and the use of grafted plants, or the remediation of agronomic problems they engender, namely water input, pollination, soil borne diseases, and reproductive problems. The break from existing cropping system requires providing technical and economic support to small producers whose investment capacity becomes a major barrier to technological adoption. Therefore, it is concluded that efforts need to be made by government to increase the effectiveness of schemes that support protected cultivation in order to have a greater impact.

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