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Chapter - 3
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Authors

Parveen Kumar Nimbrayan
Department of Agricultural Economics, CCS Haryana Agricultural University, Hisar, Haryana, India

R.S Chauhan
Department of Agricultural Economics, CCS Haryana Agricultural University, Hisar, Haryana, India

V.P Mehta
Department of Agricultural Economics, CCS Haryana Agricultural University, Hisar, Haryana, India

J.K Bhatia
Directorate of Human Resource Management, CCS Haryana Agricultural University, Hisar, Haryana, India

Chapter - 3

A Review on Economic Aspect of Protected Cultivation in India

Parveen Kumar Nimbrayan, R.S Chauhan, V.P Mehta and J.K Bhatia

Abstract

Protected cultivation is an emerging technology for raise vegetables, flowers, and others high valued as well as perishable crops. In modern agriculture, protected structures held an extreme potential for more production with higher productivity. Quantity and quality of produce is also much better than open field produces. In this review, economic aspect of protected structures was studied to analyse the production of various vegetable crops, flowers, and other high valued crops. In protected structures, production of vegetables and flowers are higher than open field conditions and productivity is also higher. Gross and net return were higher in these structures as compared to open conditions. The initial cost of protected structures is higher but it is compensated in 3-5 years with the good production of crops. Off-season vegetable cultivation and nurseries are grown under protected structures to get higher profit from it. Financial support or subsidy is also provided by the Govt. agency to spread this technology all over India. Recourse are efficiently used in these structures because modern methods/techniques were used. Protected cultivation has so much of advantages but there is some constraint also in these structures. Many of production constraints like a short life of poly sheet and severe and incidentally infestation of insect-pest and nematodes and of marketing constraints like lack of minimum support price, high price fluctuations and lack of market information were the major constraint. Initial high cost and non-availability of various material were also the major constraints in the adoption of polyhouse technology.

Keywords: Economics, Flower and vegetables, Nursery, Protected structure, Resource use efficiency.

1. Introduction

Protected cultivation is a cropping technique wherein plants are grown

under a controlled environment. The idea of growing plants in environmentally controlled condition has emerged since Roman times. The Roman gardeners used artificial methods (similar to the protected system) for growing vegetables for consumption every day (Janick *et al.,* 2007). The concept of protected structures also appeared in Netherlands and England in the 17th century. There were serious problems in providing an adequate and balanced temperature in these early protected structures. Today, the Netherlands has many of the largest poly houses in the world, some of them so vast that they are able to produce a large amount of vegetables every year (Muijzenberg and Erwin, 1980). Protected cultivation is very popular all over the world because of high valued crops are grown in these structures. For growing crops, the suitable climate conditions are must but nowadays, the climate has changed. The harsh climatic conditions like extreme heat and cold waves reduce the production and productivity of crops. During the winter season in north India, it is extremely difficult to grow vegetables in open field conditions. Because vegetables are very sensitive to climatic conditions. During summer and winter season in north India, it is extremely difficult to grow vegetables in open field conditions; however various types of protected structures have been developed for growing some high-value crops continuously by providing favourable environmental conditions and giving protection from the excessive heat and cold. Negi *et al.* (2013) studied that in upper regions of Himalayas, a majority of the population in this region live in rural areas and depend primarily (70%) on agriculture-based activities for their sustenance and prosperity. The agricultural production system is limited up to an altitude of 2400 m height from mean sea level, as the high-altitude regions have a very harsh climate and a short agriculture season. Kumar *et al.* (2006) found that agro-ecological situation of the hills offers great potential for off-season vegetable cultivation and increases farm income through the adoption of protected cultivation, wherein the microclimate surrounding the plant body is controlled fully/partially as per the requirement of the plant species grown. Greenhouses being the most efficient means to overcome climatic diversity. Greenhouse vegetable production makes the use of recent advances in technology to control the environment for maximizing crop productivity percent area and increasing the quality of vegetables produce (Wani *et al.*, 2011). These structures range in size from small sheds to industrial-sized buildings. A poly house may have different types of covering materials, such as a plastic roof and frequently, plastic walls; it heats up because incoming visible sunshine is absorbed inside the structure. Air warmed by the heat from warmed interior surfaces is retained in the building by the roof and wall; the air that is

warmed near the ground is prevented from rising indefinitely and flowing away. Commercial poly houses are often high-tech production facilities for fruit, vegetables, and flowers. These poly houses consist of equipment like screening installations, heating, cooling, & lighting and may be automatically controlled by a computer. Production of vegetables under protected conditions involves protection at the production stage of vegetables in adverse environmental conditions such as temperature, hails, scorching sun, heavy rains, snow and frost (Singh *et al.*, 1999). The protected cultivation of high-value vegetables and cut-flowers has shown tremendous potential during the last decade or so. This technology is not only creating avenues at a higher level but also to the growers with the smaller land holdings as the higher productivity levels retain economic relevance to agriculture. Since protected cultivation is a vast assembly of diverse aspects of agriculture (Sabir and Singh 2013).

2. Scenario of Protected Structures

Around 115 countries in the world are growing vegetable in greenhouse. The world scenario demonstrates the area under protected cultivation to be approximate 623.30 thousand ha while the total estimated world greenhouse vegetable production area was 402.98 thousand ha. Of the aggregate world greenhouse vegetable area, account for 95 thousand ha (Hickman, 2011). Sabir and Singh (2013) observed that in India, the area under protected cultivation in 2012-13 around 25 thousand ha while the greenhouse vegetable cultivation area is about 2000 ha. Punera *et al.* (2017) concluded that, in Himachal Pradesh the area under protected cultivation promoted by National Horticulture Mission has been found nearly 1.5 lakh ha in 2014-15. Kumar *et al.* (2018) studied that in Haryana total no. of poly house was increases 1356 to 1589 and the maximum number of poly houses was adopted in Sonepat followed by Karnal, Bhiwani and Rohtak while the minimum number of poly houses found in district Mahendergarh.

3. Types of Protected Structures

3.1 Hi-Tech Poly House

These structures are also known as fan & pad poly house. It is the costlier structure in all the protected structures because all the latest technology used in it and all operations are operated by computers i.e. irrigation, fertigation, temperature control, up and downs of plastic walls etc. High valued crops are grown in these structures. Due to higher cost, adoption of these structures is very less but the production under these structures is higher as compared to other protected structures.

3.2 Natural Ventilated Poly House

3.2.1 Tubular

These structures are manually operated. Irrigation, fertigation and all other operations are done manually. These structures come under mid-range cost structures. Cost of these structures is less than hi-tech but higher than others. In this standing structure is made up of stainless steel and wall and roof with plastic walls. Polythene sheet (150 gm thick) used in construction prevents entry of ultraviolet light, conserves CO_2 and enhances plant growth and development. Temperature and moisture inside the poly house are higher than the outside condition, which improves photosynthesis and uniform plant growth (Palni, 1996; Palni and Rawat, 2000).

3.2.2 Wooden and Bamboo

This is similar to tubular structures but the standing structure is made up of bamboo or wooden. Life of these structures is small as compared to the tubular structure. In this no specific control device used for regulating the internal environment in the poly house.

3.3 Shade Net

Shade net house is considered as one of the real innovations to provide development of healthy seedlings for various horticultural crops irrespective of climatic conditions. These structures are less costly than above structures. This protects crops from harmful ultraviolet and some infrared radiation. Along these, it protects plants from extreme summer temperatures and helps maintain air and soil moisture (Maikhuri *et al.,* 2007b). Takte *et al.* (2003) reported that shade nets were used for protection of valuable crops against excess sunlight, cold, frost, wind, and insect/birds.

Fig 1: (A) Hi-tech Poly house (B) Natural Ventilated poly house (C) Shade Net (D) Walk in tunnel (E) Plastic tunnel

3.4 Walk in Tunnel

Walk-in tunnels structure is covered with UV film, suitable for all types of crops; flowers and vegetables. These structures are small in size mostly adopted by farmers. The reason for this adaptation is lower initial cost structure. At this temperature is not controlled but internal climate is differed from outside. Sanwal *et al.* (2004) observed that in temperate areas, vegetable growers can increase their income by raising early crops in protected structures mainly in low-cost greenhouses.

3.4.1 Plastic Tunnel

These are small structures creating nursery like impact. It protects plants from harsh climatic conditions such as rain, wind, hail snow etc. These are mainly used for raising nursery. These structures are help in early seed germination. All around the year cultivation is possible.

4. Nursery Raising in Protected Cultivation

Production of off-season vegetable nurseries under protected structure has become a gainful business. The main purpose of raising nursery in the protected structure is to get higher profit and disease-free seedlings in off season to bring the early crop in protected conditions or/and open field conditions. Sanwal *et al.* (2004) studied that raising of the vegetable nursery in protected structures has many fold benefits such as easy management, early nursery, and protection from biotic and abiotic stresses. Income generated through the production of vegetable seedlings in poly house was more, followed by shade net house and open field units of the same area (Linganagouda and Mahajanashetti 2016). Ladakh is situated in the northern region of India where poly houses were to found to help in raising early nurseries of vegetables, production of early vegetable crops, an extension of growing season and vegetable production during frozen winter (Singh 2000). Raising of the rose nursery is quite difficult due to low temperature in the winter season. Looking to the importance and temperature requirement for nursery raising for proper growth in winter for rose (*Rosa chinensis*) arch shape greenhouse were selected (Senger and Kothari 2008). Nursery growing under poly house showed a significant result. In the poly house technique, more number of plants per unit area and the crop growth from it gave higher early and total fruit yields (Kang and Sidhu 2005).

5. Vegetable Cultivation in Protected Structures

In poly houses vegetable, cultivation is more popular than other crops. The reason of this because vegetables take less area to grow and their life

cycle is also short. Vegetable crops also offer better crop diversification and crop intensification. Poly house cultivation of vegetables is emerging as a specialized production technology to overcome biotic and abiotic stresses and to break the seasonal barrier to production. It also ensures round the year production of high-value vegetables, like capsicum, especially, during the off-season (Murthy *et al.*, 2009). Cheema *et al.* (2004) analysed that the higher yield of different vegetable crops inside the poly house was mainly because of a better microclimate. Protected technology enhanced crop duration as compared to an open field condition. The highest number of fruit weight and yield were achieved in poly houses as compared to open field conditions. Different protected technologies exhibited greater net return and B: C in poly house while it was lowest in open field Condition (Singh *et al.*, 2011).

In case of tomato cultivation under poly houses, the initial cost is higher due to structure cost as compared to open field conditions but at the same time, the net returns under poly houses were higher. Farmers realized a higher yield of tomato under poly house as compared to open field conditions. The gross return returns over variable cost and net return were also higher in case of poly house as compared to open field conditions (Kumar *et al.*, 2016). Bhatnagar *et al.* (1990) observed that tomato have maximum yields inside the greenhouse as compared to open field conditions. Tomato crop grown under poly house conditions were earlier to flower and had a higher yield than those in the field. Capsicum crop grown in the naturally ventilated poly house showed four times more yield and yield components compared to those grown in the open field. Cauliflower grown in the poly house showed the shorter duration of curd formation than those in the field (Nagalakshmi *et al.*, 2001). In the marketing of tomato produce of poly houses, farmer use various market channel to sell their produce. The least share in consumer's rupee was observed in Channel Distant market. As far as marketing efficiency was concerned, producer → consumer channel was found most efficient among all other marketing channels (Bhatia *et al.*, 2017).

Capsicum is also growing at large scale in poly houses. In poly house, the overall cost of cultivation of capsicum under poly house was higher compared to open field conditions due to structure cost but the net returns under poly houses were higher. The capsicum cultivation under poly houses has significantly contributed to the yield (Kumar *et al.*, 2016). Bhatnagar *et al.* (1990) reported that during winter, in the hilly region of Uttar Pradesh, capsicum was grown under greenhouse with increased yields of 50 quintals

per ha as compared to those in open fields (24 q/ha). The yield of capsicum per square meter of the cultivated area in the greenhouse was found to be 2.34 times more than open field condition. The B: C ratio for capsicum in the greenhouse was 2.98 whereas it was 0.80 in case of open field condition. In this naturally ventilated type of greenhouse, the small and marginal farmers of Odisha will be able to grow other vegetables during the off-season which would be quite remunerative (Ghosal 2012). In protected structure, the fixed cost is more than the variable cost and in variable cost, a large proportion was spent on labour because in these structures skilled labour is used. The total yield of capsicum production under protected conditions is high. The total returns and net returns from capsicum production under protected conditions were higher (Sreedhara *et al.*, 2013). Under shade net, the crop yield was increased by 80 per cent over open field cultivation along with water saving of about 40 per cent in covered cultivation (Rao *et al.*, 2013). Sometimes the economics of bell pepper under natural ventilated poly house (NVPH) were changing due to additional application of material (Bharti *et al.*, 2017). After harvesting of capsicum, the produce is selling in the market. The farmer gets the maximum share in consumer rupee from direct marketing of capsicum. Whereas least share of consumers rupee was observed in the distant market. As far as marketing efficiency was concerned, Producer to direct Consumer Channel was found most efficient (Bishnoi *et al.*, 2017).

Similarly, in the cost of cultivation of cucumber per acre under poly house was higher as compared to open field condition. In case of production and net returns, it was higher per acre in poly house. The yield and income of farmers can be increased with help of poly house technology in case of cucumber cultivation (Kumar *et al.*, 2017). B: C ratio for cucumber cultivation under greenhouse condition is higher (Malik 2017). In Kerala cucumber producing in naturally ventilated low-cost poly house. If the cucumber was fertilized at the rate equal to the 100% of the recommended dose, the highest (3.42) B: C ratio was obtained (Chand 2014). Sanjeev *et al.* (2015) found that economic feasibility of cucumber cultivation under low-cost naturally ventilated poly houses successively for two years - 2013 and 2014. The B: C ratios (without any government subsidy) of 1.36 and 0.55 were observed for the years 2013 and 2014 respectively. This economic analysis concluded that the capital cost of the structure and market price of the product affected the returns greatly. In protected cultivation with the construction of hi-tech polyhouse and low-cost shade-net house for the cultivation of vegetable such as Tomato, Spinach beat, Cucumber was grown. The B: C ratio for the hi-tech greenhouse and low-cost shade-net

house for the cultivation of vegetable year around was 1.48:1 and 2.29:1, respectively. Thus, protected cultivation could be the only one alternative to control the environment for maximizing crop productivity percent area and increasing the quality of vegetables produce round the year (Chakraborty and Sethi 2015). In protected cultivation majorly three crop rotations were used i.e. tomato-cucumber, capsicum-cucumber and cucumber-cucumber-cucumber rotation. In this, more cost of cultivation was found in the cucumber-cucumber-cucumber rotation while less was found in capsicum-cucumber under poly houses. Gross return was highest in crop rotation of cucumber-cucumber-cucumber followed by tomato-cucumber and capsicum-cucumber, respectively while net return was higher in cucumber-cucumber-cucumber (Kumar *et al.*, 2017). The techno-economic analysis of various low cost naturally ventilated poly houses constructed in various regions of India under the project 'All India Coordinated Research Project on Use of Plastic in Agriculture'. In 2007, bamboo framed poly houses in Uttarakhand region were evaluated for off-season crop sequence: vegetable pea (Dec.-Mar.; season I)-summer squash (Mar.-Jun.; season II)-Tomato (Jul.-Nov.; season III). The study showed the B: C ratio between 1.64 to 2.2 for different sizes of poly houses. This research also suggested minimum greenhouse area of 80 m^2 (with a typical dimension of 16 m X 5 m) for better production and profit. Also, low cost naturally ventilated bamboo poly house was evaluated in Meghalaya region. Under poly house conditions, production of tomato and eggplant seedlings were respectively 38% and 32% higher and seedlings were ready for transplanting 10-12 days early compare to outside open conditions. When the low-cost poly houses tested for two cropping sequences: capsicum-tomato lettuce and tomato-French bean-cabbage, B: C ratios observed were 2.1 and 1.7 respectively (Bhatnagar 2014).

6. Flower Cultivation in Protected Structures

Flower cultivation in protected structure nowadays used as commercial agriculture for better quality and more profit. Quality of flower raised in these structures is significantly better than the open condition that's why these are mostly used for export. Punera *et al.* (2017) studied that the carnation cultivation has been most profitable vis-a-vis domestic market-oriented and diversified pattern of production. Cost of protected cultivation can also have recovered in 3-5 years, depending upon the crops grown. The internal rate of return (IRR) varies from 31 per cent for carnation with capsicum to 73 per cent when the only carnation is grown. Wadkar *et al.* (2006) tells that in cut-flowers profitability under polyhouse conditions has been found the maximum in orchid and minimum in rose. But in another

study the economic feasibility of major flower crops (rose, carnation, lilium, gerbera, and chrysanthemum) grown in Himachal Pradesh province of India. All the crops were cultivated in the low cost naturally ventilated galvanized iron pipe framed polyhouses. The B: C ratio for roses, carnation, lilium, gerbera, and chrysanthemum were respectively observed to be 2.89, 2.37, 1.89, 2.01, and 2.39, suggesting that the rose cultivation might be the most beneficial option (Sharma *et al.*, 2014). The estimated production costs of rose cut flowers in polyhouses in Maharashtra were higher with the higher production of flowers produced per day while in open field cost is less but flower production is less (Tilekar and Nimbalkar 1999). The three different genotypes of carnations viz. Soto, Dona, and white Dona were evaluated. The B: C ratios of these genotypes were found respectively as 2.50, 2.00 and 1.85 (Tarannum *et al.*, 2014). Sometimes economics of carnation cut flower production was significantly influenced by the fertilizer application. Carnation cv. Master plants fertigated with 250 ppm N and K through urea and MOP in combination with 250 ppm NPK foliar spray through Sujala (19:19:19 NPK) once a week produced maximum saleable flowers for three flushes over the recommended practice. The same treatment also recorded maximum returns of with highest B: C ratio of 2.27 for three flushes (Singh *et al.*, 2016). In protected structures, the actual expenditure on account of human labour is maximum because of skilled labour followed by planting material, plant protection, value of land. Protected cultivation hold good potential for employment and the area under cultivation needs to be increased (Tilekar and salunkhe 2001).

7. Resource Use Efficiency of Protected Structures

Protected cultivation involves the intensive use of resources such as soil, water, fertilizers, pesticides, and energy. Polyhouse increased production and productivity per unit of land, water, energy and labour, high quality and clean products, high water and fertilizer use efficiency, subsidy provision for establishment of high cost infrastructure, round the year employment to the farmers were the major prospective aspects perceived by poly house farmers (Ghanghas *et al.*, 2018). The greenhouse of the future will have nearly zero environmental impact. This goal can be achieved by developing a sustainable greenhouse system that: does not need any fossil energy and minimizes the carbon footprint of equipment; with no waste of water nor emission of fertilizers and full recycling of the substrate; with minimal need of plant protective chemicals, yet with high productivity and resource use efficiency. The greenhouse of the future can fulfill the need for the safe use of resources (energy, water, pesticides) through modification of greenhouse

design and management. The greenhouse can benefit from the reduction of waste through better management of irrigation and climate (Stanghellin and Montero 2012). A manifold increase in the resource-use efficiency in crop production can be obtained through protected cultivation compared to open-field conditions. In protected cultivation, high-value cash crops, vegetables, and flowers are grown and managed under controlled conditions with higher per unit productivity and profitability (Choudhary 2016). Polyhouse cultivation is an alternative new technique in agriculture to picking up position in rural India. It diminishes reliance on rainfall and makes the ideal utilization of land and water assets because of the guaranteed framework. In polyhouses, the water is supplied by drip irrigation with due effect, water is less utilized when contrasted with open cultivation. In open field conditions nearly one-third of the crops may be lost due to the attack of insects and worms, whereas in polyhouses farming, we can harvest the crops about 2 to 3 times more without much damage or loss. Polyhouse farming can help the farmer generate income around the year growing multiple crops and fetching premium pricing for off-season vegetables (Kumar *et al.*, 2017).

8. Constraint in Protected Structures

The greenhouse technology can be a key for sustainable crop production and to accomplish food security in the regions confronting the issues of food scarcity. It gives guaranteed crop production and also increases the productivity. But, the high initial cost is one the greatest worry in the adoption of the technology by the farmers (Jadhav and Rosentrater 2017). Protected cultivation is emerging 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 were the major production constraints, whereas lack of minimum support price, high price fluctuations and lack of market information were the major of marketing constraints (Kumar *et al.*, 2016). Farmers also face population explosion of minute insects like mites & whiteflies, especially the white fly menace, frequent occurrence of windstorms, hailstorms, lack of cold storage facilities in villages, high cost of refrigerated vehicle and problem of nematode infestation were the foremost serious constraints faced by the poly house growers (Ghanghas *et al.*, 2018). The constraints related lengthy loan procedure, a high cost of production, and non-availability of quality seedlings. In the case of marketing, the major constraints reported by the farmers include non-payment of prices by commission agents in accordance with the grade of flowers, non-transfer of payments to producers in time and the high cost of transportation (Wadkar *et al.*, 2006). Higher initial

investment, lack of technical guidance and the high cost of pesticides and fertilizers were the major productions related problems faced by the respondent farmers (Malik 2017). Sanwal *et al.* (2004) concluded that the high cost and non-availability of various parts are the two major constraining elements in the adoption of polyhouse technology for commercial cultivation. Greenhouse and different structures plan for various agro-climatic of the region are not standardized. 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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