Indian Journal of Agricultural Sciences **87** (4): 485–90, April 2017/Article

Constraints in adoption and strategies to promote polyhouse technology among farmers: A multi-stakeholder and multi-dimensional study

ITIGI PRABHAKAR[1], K VIJAYARAGAVAN[2], PREMLATA SINGH[3], BALRAJ SINGH[4], JANAKIRAM[5], B L MANJUNATHA[6], SEEMA JAGGI[7] and I SEKAR[8]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received: 5 November 2015; Accepted: 20 September 2016

ABSTRACT

The study was conducted on 120 farmers and 30 agricultural researchers each of two states, viz. Maharashtra and Karnataka to delineate the constraints in adoption of polyhouse. The farmers faced environmental, technical, labour, economic and marketing constraints in harnessing profitability and sustainability of this technology. The major constraints in rapid adoption were high initial investment, poor availability of quality planting material and inputs, poor post-harvest infrastructure and absence of price policy measures. Farmers of Maharashtra were found to be better placed with respect to market access and availability of quality planting material. All the stakeholders agreed that R&D initiatives were required to develop low cost designs and reduce the cost of cultivation under polyhouse. Farmers' ability to successfully integrate this technology to suit their socio-economic and agro-ecological conditions would further affect its profitability and sustainability.

Key words: Adoption, Constraint, Market access, Polyhouse technology, Post-harvest infrastructure, Price policy, Stakeholder

Due to the adverse effects of the green revolution on soil fertility, emergence of new insect pests and diseases and declining of water table level (Jain 2010) tempted the farmers to consider alternate methods of cultivation which could curb the adverse effects of green revolution and provide an opportunity to grow crops throughout the year. Protected Cultivation Technology was one such alternative which was promising to the farmers. Climate change and poor water availability will necessitate growing more food with less and less water.

The scope of area expansion under cultivation of vegetables and flowers is very little. The only option is vertical expansion through increased productivity and cropping intensity using protected farming with environment control measures, quality seeds, fertilizers and plant protection measures (Paroda 2013, Gowda 2009, NAAS 2001, GOH 2013, Singh and Brahma 2012, Singh *et al.* 2005, Singh *et al.* 2004). Plastic mulching, protected nursery production, use of green/polyhouses/ shade net houses for off-season production of vegetables and flowers have consistently given good results both at research farms and farmers' fields (Singh *et al.* 2004). In the recent years increasing attention has been focused on several environmentally safe methods of pest management, including polyhouse cultivation to reduce pesticide use mainly because of growing concern over food safety issues and environmental concerns.

India has entered into an era of greenhouse vegetables cultivation more recently and the total area under protected vegetable production is not more than 10000 ha (Mayanglambam and Nisha 2013). India being a vast country with diverse and extreme agro-climatic conditions, the protected cultivation technology can be utilized for year round off-season production of high value, low volume vegetables, production of virus free quality seedlings, production of quality hybrid seeds and as well as for disease resistance breeding programmes. However, adoption of polyhouse technology varies widely across the states in India. The protected cultivated technologies especially polyhouse technology required high initial investment and that major adopters of these technologies were large farmers. In this context, it is important and topical to delineate the constraints and challenges that farmers face in adoption of polyhouse technology. This would help in finding out the determinants of adoption which play a significant role in devising strategies to overcome the challenges.

MATERIALS AND METHODS

The study was conducted in two states namely,

[1]Assistant Professor (e mail: prabhakariari@gmail.com), University of Horticultural Sciences, Bagalkot, Karnataka. [2,3,8]ICAR-Indian Agricultural Research Institute, New Delhi. [4]ICAR-National Research Center on Seed Spices, Ajmer, Rajasthan. [6]ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan. [7]ICAR- Indian Agricultural Statistics Research Institute, New Delhi.

Karnataka and Maharashtra during 2013. These states were purposively chosen since these are the leading states in area under protected cultivation. Two districts from each state, viz. Bengaluru Rural and Belgaum from Karnataka and Pune and Sangli districts from Maharashtra were selected purposively because of highest area under protected cultivation in these districts. In total 120 farmers (30 farmers from each district) who had adopted polyhouse technology were selected by using stratified random sampling technique.

The sample also consisted of 30 officials from the State Department Agriculture/ Horticulture (including National Horticulture Mission and National Horticulture Board officials) of Karnataka and Maharashtra; 30 researchers from State Agricultural Universities (SAUs) and Indian Council of Agricultural Research (ICAR) organizations involved in Research and Development and promotion of PCTs among farmers; and 30 respondents belonging to agencies involved in production and marketing of Protected Cultivation Technology (PCT) equipments and technology to farmers (dealers and retailers). All the stakeholders other than farmers were selected purposively based on their expertise and experience in R&D, dissemination and marketing of polyhouse technology.

An exhaustive list of constraints was prepared and the respondents' opinion in the study area on constraints was measured on a five point continuum scale of very severe, quite severe, severe, not so severe and least severe with score of 5, 4, 3, 2 and 1 respectively. Relevancy Ranking Technique was used with the following formula:

$$RC_i = \frac{\text{Total score of all the respondents for } i^{th} \text{ constraint}}{\text{Maximum on the continuum} \times \text{Total number of respondents}}$$

RC_i refers to Relevancy Coefficient for the i^{th} constraint. The ranking of each constraint was made according to its relevancy coefficient such that the constraint having the highest relevancy coefficient is ranked 1st and subsequent rank given according to the scores obtained in that order.

The strategies to overcome the challenges faced by farmers in adoption of polyhouse technology were pooled based on discussions with all the respondents of the study. Strategies were tabulated and analyzed using Garrett's ranking technique.

RESULTS AND DISCUSSION

Constraints in adoption of polyhouse technology

Environmental constraints

The environmental constraints faced by farmers in adoption of polyhouse in Maharashtra and Karnataka have been presented in Table 1.

Over-exploitation of nutrients from soil has led to their decline in fertility status, especially in Maharashtra. Scarcity of water for irrigation was another major problem for farmers of Karnataka and Maharashtra. Highly erratic weather conditions outside the polyhouse lead to higher care and better management of crops inside the polyhouse and inturn higher cost of cultivation. Occurrence of pest and diseases inside the polyhouse sometimes exceed when compared to open cultivation because of favourable climatic conditions (high moisture and humidity) inside the polyhouse. Continuous irrigation to soil through drip or mist irrigation or water spray inside the polyhouse has also led to poor drainage conditions. Farmers of Maharashtra and Karnataka also reported loss in production because of physiological disorders. Paroda (2013) reported that among the major constraints in production of horticultural crops in India are temperature (hot or cold), sunlight duration and quality, water deficiencies or excesses, atmospheric moisture (relative humidity), weeds, deficiency of nutrients, heavy winds, carbon dioxide and host of diseases and insect pests.

Table 1 Environmental constraints as perceived by farmers in adoption of polyhouse technology (n=120)

Constraint	Maharashtra		Karnataka	
	Relevancy coefficient	Rank	Relevancy coefficient	Rank
Relatively higher perishability of flowers/ vegetables	0.91	I	0.93	I
Scarcity of water for irrigation under polyhouse	0.64	IV	0.79	II
Highly fluctuating weather conditions	0.62	V	0.76	III
Poor drainage of soil	0.59	VI	0.69	IV
Low soil fertility status	0.75	II	0.64	V
Occurrence of pest and diseases	0.72	III	0.59	VI
Occurrence of physiological disorders	0.46	VII	0.49	VII

Technical constraints

Production of crops under polyhouse conditions is highly knowledge and skill intensive. However, farmers find it difficult to get the latest information and techniques of crop production under polyhouses, especially in their regional languages. Availability of quality planting material at reasonable prices is a challenge. The fact that planting material is supplied only by few private players has resulted into farmers being completely dependent on them.

The technical constraints faced by farmers have been presented in Table 2. Farmers of Karnataka expressed that availability of package of practices for cultivation of crops under polyhouse is either limited or requires lot of modification to suit their agro-ecological and socio-economic conditions.

Availability of quality seed and planting material of required cultivar is a severe constraint faced by farmers on account of increased dependence on formal sector especially private seed companies (Manjunatha *et al.* 2013a,

Table 2 Technical constraints as perceived by farmers in adoption of polyhouse technology (n=120)

Constraint	Maharashtra		Karnataka	
	Relevancy coefficient	Rank	Relevancy coefficient	Rank
Lack of scientific knowledge about crop production under polyhouse	0.72	V	0.89	I
Non-availability of required quantity and quality planting material at right time	0.66	VI	0.77	II
Limited and irregular power supply	0.93	I	0.69	III
Non-availability of quality inputs like pesticides and insecticides at right time	0.45	VIII	0.64	IV
Non-availability of quality polyhouse equipments at local market	0.55	VII	0.59	V
Lack of technical guidance about production techniques	0.82	III	0.56	VI
Lack of relevant literature in local language	0.83	II	0.48	VII
Difficulties in following the recommended practices	0.76	IV	0.30	VIII

Manjunatha *et al.* 2015a, and Manjunatha *et al.* 2016). Singh (2006) also reported that no specific breeding work had been initiated for development of suitable varieties/ hybrids for greenhouse or protected cultivation, even in important vegetables, viz. tomato, cherry tomato, sweet pepper and cucumber.

However, it was interesting to note that limited power supply was the major constraint for the farmers of Maharashtra. Farmers of Maharashtra have entered into advanced stage of polyhouse cultivation and are in the process of expanding the area under polyhouse cultivation. Hence, power supply acts as critical input. Farmers of Karnataka are still in the initial phase of polyhouse technology adoption wherein availability of quality planting material and inputs are important issues.

Labour related constraints

Polyhouse cultivation is labour intensive and demands skilled labour throughout the year. Not surprisingly, availability of skilled labour is a critical issue for farmers in both Maharashtra and Karnataka (Table 3).

Migration of rural folk to urban areas in search of better jobs, alternative employment opportunities at the village level (including MNREGA scheme) and indifferent attitude of youth towards agriculture has led to acute shortage of skilled labour especially in the peak seasons of planting/ sowing and harvesting. This has naturally raised the wage rates of skilled labour required for polyhouse cultivation. The average per day wage rates in the peak season of sowing/ planting and harvesting in the open field conditions in the study area was ₹ 150 for women and ₹ 200 for men, whereas in the polyhouse the per day wage rates ranged between ₹ 250–300 for women and ₹ 300–400 for men. It was estimated that average annual expenditure on wages and salaries in the first three years of establishment of polyhouse is ₹ 77000/unit. A unit is a standard measure of area under polyhouse cultivation and is equivalent to 1008 sq meters.

Table 3 Labour constraints as perceived by farmers in adoption of polyhouse technology (n=120)

Constraint	Maharashtra		Karnataka	
	Relevancy coefficient	Rank	Relevancy coefficient	Rank
High cost of skilled labour	0.72	II	0.96	I
Scarcity of labour during peak seasons	0.91	I	0.76	II
Lack of availability of skilled labour	0.53	III	0.44	III

Economic constraints

The economic constraints of the farmers in adoption of polyhouse presented in Table 4 shows that the initial cost required to establish a polyhouse is still very high and is beyond the reach of small and medium farmers. The expenditure incurred by farmers in establishing polyhouse, cost of planting material and its maintenance is given in Table 5.

The cost of establishment of polyhouse varies between ₹ 1.2 million to ₹ 1.4 million. Polyhouse cultivation requires quality planting material, inputs, etc. which adds economic burden to the farmers. Singh (2006) also reported that the basic cost of fabrication and the operational cost of the climate-controlled greenhouses are very high, which are

Table 4 Economic constraints as perceived by farmers in adoption of polyhouse technology (n=120)

Constraint	Maharashtra		Karnataka	
	Relevancy coefficient	Rank	Relevancy coefficient	Rank
High initial investment in construction of poly house	0.83	I	0.89	I
High cost of planting material	0.36	VIII	0.83	II
High cost of plant protection chemicals	0.62	V	0.65	III
Lack of adequate and timely disbursement of loan from financial institutions	0.81	II	0.59	IV
High cost of transportation	0.28	IX	0.53	V
Complexity of loan procedure	0.72	III	0.46	VI
Lack of awareness about credit and subsidy facilities	0.42	VI	0.42	VII
Poor accessibility to subsidy	0.65	IV	0.35	VIII
Absence of crop insurance scheme for flowers and vegetables	0.41	VII	0.30	IX

not suitable to the growers in India.

Seeds of commercial crops and low-volume, high-value crops were costly because of inclusion of royalty/trait fee in the retail price (Manjunatha *et al.* 2015b). Protection, enforcement and maintenance of IPRs over seed and genetic material by private seed companies through PPVFRA 2001 will also add cost and these costs are passed on to consumer farmers (Manjunatha *et al.* 2013b).

The poor accessibility to subsidy and absence of pricing policy including crop insurance has further increased the risk of polyhouse cultivation. The upper ceiling limit of subsidy varies from scheme to scheme but generally it ranged between 20 to 50 per cent of the cost of erection of polyhouse. Even the ceiling on area under polyhouse for availing subsidy benefits is maximum of one unit (1008 sq m).

The farmers of both Maharashtra and Karnataka expressed that it took minimum of eight months after application, to avail loan facilities from financial institutions and commercial banks.

Marketing constraints

The marketing constraints faced by the farmers have been presented in Table 6.

Indian farmer is a price taker and not a price fixer. It is more so in crops where price policy is completely absent as in case of flowers and vegetables. Hence, unfavorable market prices may cause huge financial losses. Farmers fetched good prices from international markets when compared to domestic market. Even in the domestic market, farmers fetched good prices during the months of January-April and the season is generally slack during September to December.

Saini (2012) emphasized the importance of Government intervention in the price policy mechanism to prevent price fluctuation. The deficiencies in the infrastructure such as poor grading and transport facilities and cold chain management combined with market malpractices add to the risk component of farmers in India. The markets for polyhouse products are generally exclusive and far, sometimes crossing the boundary of the nation. The average distance from the nearest market (Pune and Solapur) for farmers of Pune and Sangli in Maharashtra ranged between 60 to 80 km, whereas it was less than 60 km for farmers of Bengaluru Rural district. The average distance from nearest market (Pune and Solapur) for Belgaum farmers is more than 200 km and hence they had to incur very high expenditure on transportation costs.

The International Flower Auction Bangalore (IFAB) is a public sector market exclusive for flowers and is nearest for the farmers of Bengaluru Rural district. However, farmers from Bengaluru Rural district expressed that this market is inaccessible because of its location in the center of the city. Hence, they preferred to sell their produce in another non-exclusive market (K. R. Market). It indicated that location of market is also very important as it affects cost of transportation.

Table 6 Marketing constraints as perceived by farmers in adoption of polyhouse technology (n=120)

Constraint	Maharashtra		Karnataka	
	Relevancy coefficient	Rank	Relevancy coefficient	Rank
Fluctuation in market prices	0.61	IV	0.77	I
Lack of marketing facilities at local place (block/district headquarters)	0.44	V	0.68	II
Lack of exclusive markets for flowers/ vegetable grown under polyhouse	0.37	VI	0.52	III
Existence of middle men malpractices	0.83	I	0.44	IV
Lack of specialized supply chain management including cold chain	0.34	VII	0.39	V
Difficulty in grading the produce at the production level	0.74	II	0.36	VI
Distress sale due to immediate need of money	0.71	III	0.32	VII

Strategies to expedite the rate of adoption of polyhouse technology

The strategies reflect the priorities as perceived by various stakeholders to enhance adoption of polyhouse technology among farmers. The strategies as perceived by farmers to increase the rate of adoption of polyhouse technologies are presented in Table 7.

Mayanglambam and Nisha (2013) also reported that some poor quality produce with pesticide residues has been a matter of great concern. These issues can easily be addressed by integrating various production and protection practices including location specific designing and construction of the polyhouses for efficient input use. Efforts such as investment in marketing facilities and creating new markets for polyhouse products will enhance the profitability from polyhouse cultivation.

Farmers also need to take appropriate and scientific measures in selection of location and site for polyhouse cultivation and its proper management. Use of certain Indigenous Technical Knowledge (ITKs) and locally available resources may prove beneficial for increasing the efficiency and sustainability of polyhouse cultivation and mitigation of risk. Working Group Report on Development of Protected Cultivation in Haryana (2013) suggested that innovative marketing approaches such as cluster and cooperative based marketing will increase the bargaining capacity of farmers thereby giving them power to fix the prices of their products in the markets. Paroda (2013) reported that Government support needs to be extended for self-fabrication module of temporary low-cost structures like insect-proof net houses, shade net houses, walk-in-tunnels, and self fabricated low-cost protected structures for production of vegetables and flowers. There is a need

Table 7 Strategies to expedite the rate of adoption of polyhouse technology as perceived by farmers

Strategies	Maharashtra		Karnataka	
	Garrett Mean Score	Rank	Garrett Mean Score	Rank
Policy initiatives				
Price policy mechanism	64.88	II	89.525	I
Regular power supply (three phase)	77.53	I	78.025	II
Timely availability of quality planting material locally	61.89	III	64.875	III
Higher subsidy for protected cultivation under polyhouse	55.41	IV	43.088	IV
Creation of primary processing facilities at farm gate level	45.49	V	28.231	V
Research and development initiatives				
Reducing the high initial investment	78.63	I	79.625	I
Reducing the cost of cultivation	61.82	III	68.562	II
Standardization of designs and structure of low cost polyhouse for different agro-climatic regions of the country	77.57	II	65.451	III
Development of user-friendly Package of Practices	50.63	V	50.698	IV
Standardization of production technology under polyhouse	36.55	IV	48.854	V
Marketing initiatives				
Availability of raw material of required quality at local market	42.48	IV	79.250	I
Promotion of direct marketing and forward marketing of the produce	58.55	III	61.587	II
Creation of separate cargo flights for national and international markets to export the produce	75.54	I	56.258	III
Creation of specialized brand for the produce and specialized market for the produce	63.59	II	41.658	IV
Famer level initiatives				
Cluster and cooperative based approach in production and marketing of produce	61.66	II	86.578	I
Appropriate selection of location and site for polyhouse installation	77.65	I	71.865	II
Installation of rain water harvesting technique to reduce irrigation cost	49.83	IV	52.598	III
Use of indigenous technical knowledge for control of temperature and humidity	43.66	V	48.962	IV
Reducing polyhouse installment cost by using locally made material	58.55	III	41.857	V

Table 8 Strategies to expedite the rate of adoption of polyhouse technology according to other stakeholders

Strategies	Garret Mean Score	Rank
Researchers from SAUs/ICAR Institutes (N= 30)		
Design and development of low cost and location specific polyhouse technology	85.33	I
Development of new varieties and hybrids/ superior planting material of flowers and vegetables suitable for protected cultivation	75.22	II
Development of user-friendly package of practices under protected cultivation	69.26	III
Conducting research to reduce the post-harvest losses of the produce produced under protected cultivation	47.89	IV
Officials from State Department of Agriculture/Horticulture/ National Horticulture Mission/ National Horticulture Board (N= 30)		
Increasing the ceiling limits of area under cultivation and amount of subsidy for protected cultivation	85.26	I
Efficient and transparent implementation of loans and subsidies to beneficiary farmers	81.26	II
Creation of world class post-harvest infrastructure including grading, packaging, cold chain management and export facilities	71.49	III
Incentive pricing policy for polyhouse grown vegetables and flowers	63.12	IV
Officials of agencies involved in production and marketing of polyhouse equipments and technology to farmers (dealers and retailers) (N= 30)		
Investment by private sector in development of infrastructure related to market such as storage, grading, packaging and cold chain management	87.59	I
Government initiative for development of infrastructure related to market such as storage, grading, packaging and cold chain management	70.25	II
Promotion of GAP under polyhouse cultivation among farmers	69.57	III
Improving the accessibility of the quality planting materials, inputs and equipments required for protected cultivation	54.26	IV

for regular uninterrupted power supply to maintain optimal growing conditions within protected structures. To provide better return to the farmers, there is a need to provide support with proper market linkages, market intelligence and supply chain management including cold chain.

The strategies as perceived by other stakeholders to increase the profitability and sustainability of polyhouse technology and its adoption are presented in Table 8.

The researchers from SAUs/ICAR Institutes expressed that development of low cost designs and equipments for

polyhouse technology, development and multiplication of quality planting materials, development of farmer-friendly package of practices and low cost post-harvest operations to reduce losses were the research priorities to be addressed by public sector research institutes.

Agriculture Department officials suggested that subsidy schemes for polyhouse cultivation required certain reforms. Since farmers expect subsidy from government to establish polyhouses, Agricultural Development Officers (ADOs) expressed that expanding the basket of beneficiaries under subsidy scheme along with increasing the existing ceiling limits for area under polyhouse cultivation and subsidy amount will act as a strong incentive for farmers to adopt and expand this technology. ADOs also expressed the responsibility of Government for development of post harvest and market related infrastructure.

However, the priorities of marketing agencies revolve around improving the accessibility of technologies and inputs to farmers and need for establishment of marketing infrastructure by Government. They also opined that investment in developing infrastructure must be made to spur adoption of polyhouse technology. Adoption of Good Agricultural Practices (GAP) by farmers would further increase the market value and export potential of their produce.

High initial investment, lack of availability of quality planting materials and inputs, poor post harvest infrastructure and absence of price policy have led to very limited adoption of this technology by few farmers in certain pockets of the country. Favourable policy measures such as expanding the scope and amount of subsidy; provision of quality planting material and inputs at affordable prices; investment in infrastructure to plug post harvest losses and pricing policy would enhance the profitability and sustainability along with increasing the adoption of this technology. Research and Development initiatives should aim at developing low cost designs and reducing the cost of erection of polyhouse and cost of cultivation. The re-inventions in design and structure of polyhouse by farmers also credit due recognition and attention of research and extension agencies. The success of adoption of this technology also depends on how well the farmers integrate this technology on their farm to suit their socio-economic and agro-ecological conditions.

REFERENCES

GOH. 2013. Working Group Report on Development of Protected Cultivation in Haryana. Haryana Kisan Ayog, Government of Haryana, pp 1–66.

Gowda S M V. 2009. Hi-Tech Floriculture in Karnataka, Occasional Paper-49, The National Bank for Agriculture and Rural Development Department of Economic Analysis and Research, Karnataka Orion Press, Fort, Mumbai, pp 1–95.

Jain H K. 2010. The Green Revolution: History, Impact, and Future. Studium Press.

Manjunatha B L, Rao D U M and Dastagiri M B. 2013a. Trends in seed production, growth drivers and present market status of Indian seed industry: An analytical study. *Indian Journal of Agricultural Sciences* **83**(3): 315–20.

Manjunatha B L, Rao D U M, Dastagiri M B, Sharma J P and Burman R R. 2013b. The legal protection of public and private plant varieties in India: A comparative study. *Journal of Bioremediation and Biodegradation* **4**(7): 1–5.

Manjunatha B L, Rao D U M, Sharma J P, Burman R R, Hajong Dipika, Dastagiri M B and Sumanthkumar V. 2015a. Factors affecting accessibility, use and performance of quality seeds in Andhra Pradesh and Bihar: Farmers' experiences. *Journal of Community Mobilization and Sustainable Development* **10**(1): 130–45.

Manjunatha B L, Rao D U M, Dastagiri M B, Sharma J P and Burman R R. 2015b. Need for government intervention in regulating seed sale price and trait fee: A case of Bt cotton. *Journal of Intellectual Property Rights* **20**(6): 375–86.

Manjunatha B L, Rao D U M, Dastagiri M B, Sharma J P and Burman R R. 2016. New Indian Seeds Bill: Stakeholders' policy advocacies to enact. *Journal of Intellectual Property Rights* **21**(2): 73–8.

Mayanglambam B D and Nisha Thakur. 2013. Protected cultivation as an emerging agri-entrepreneurship in hilly regions of India. *Popular Kheti* **1**(1): 21–5.

NAAS. 2001. Hi-Tech Horticulture in India, Policy Paper, National Academy for Agricultural Sciences, pp 1–9.

Paroda R S. 2013. Strategies for protected cultivation. Inaugural Address, delivered at the first National Seminar on Advances in Protected Cultivation, at NASC Complex, Pusa Campus, New Delhi.

Saini A S. 2012. Present and future State policies for promotion of protected cultivation of vegetables and flowers, processing and marketing of produce, gaps and recommendations. Paper presented in Stakeholders meeting on Protected Cultivation For Haryana, held at Haryana Kisan Ayog, Kisan Bhawan, Khandsa Mandi, Gurgaon on 8th February 2012.

Singh B and Sirohi N P S. 2006. Protected cultivation of vegetables in India: Problems and future prospects. *In* International symposium on greenhouses, environmental controls and in-house mechanization for crop production in the tropics and sub-tropics. ISHS *Acta Hort*: 710.

Singh Balraj, Kumar, Mahesh and Rathi Soniya. 2004. Diversification in horticulture through protected cultivation of vegetable crops. *Diversification in Horticulture* **42:** 43–7.

Singh, Balraj, Kumar, Mahesh and Singh Veerpal. 2005. Cultivating tomato in greenhouse is lucrative. *Indian Horticulture* **49**(4): 13–4.

Singh, Brahma. 2012. Protected cultivation of vegetables and flowers-potentials and success stories in India and Abroad. (*In*) Stakeholders meeting on Protected Cultivation For Haryana, held at Haryana Kisan Ayog.