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Protected cultivation in Maharashtra: determinants of adoption, constraints, and impact$

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Abstract Under the National Horticulture Mission, protected cultivation is practised in the Pune and Nasik districts of Maharashtra. The cost of protected cultivation of rose and capsicum is over 300% of the cost of open cultivation; the gross return is 250% and net return 190%. Adoption is influenced by age, education, household income, landholding size, and distance to market. The high capital investment and cost of planting materials, and the incidence of pests and diseases were major constraints to adoption. Farmers will continue to adopt protected cultivation depending on their risk-bearing ability and government support.

Keywords Economics of protected cultivation, technology, adoption index, horticulture crops, impact, principal component analysis, Tobit regression, Garrett's ranking

JEL Codes Q12, Q16, Q17, Q18

India's agriculture development strategy, focused in the past on improving the agricultural output and food security (Chand 2017), now aims at doubling farmers' real income by 2022 over the base year of 2015 to reduce agrarian distress and make agricultural and non-agricultural professional income equal. The goal of doubling farmers' income can be achieved using agronomic technologies such as protected cultivation.

Protected cultivation provides crops a controlled environment and protection from adverse climatic conditions, using innovative structures (greenhouses, net houses, screen houses, tunnels) or protections (windbreaks, irrigation, mulches) (Sylvan and Nicolas 1995; Sabir and Singh 2013). Inputs like fertilizers, pesticides, and water are utilized more efficiently than in open field conditions (Stanghellini and Montero 2012; Mehta et al. 2020), and improved productivity and quality ensures higher returns for the produce. Protected cultivation lets farmers produce crops off season and fetch higher prices (Sabir and Singh 2013; Prabhakar et al. 2017).

The technology of protected cultivation emerged in India in the early 1990s. The liberalization of industrial and trade policy paved the way for the development of export-oriented cut flowers. The programmes and incentives of the central and state governments led to a substantial increase in the area under protected cultivation. Prakash et al. (2019) estimate that about 215,000 hectares of land was brought under the National Horticulture Mission between 2005–06 and 2017–18. The area under protected cultivation is highest in Chhattisgarh, Odisha, Andhra Pradesh, Gujarat, Madhya Pradesh, and Maharashtra.

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To assist farmers in adopting the practices of protected cultivation, the central government instituted institutions such as the National Horticulture Mission and National Horticulture Board, and schemes such as the Rashtriya Krishi Vikas Yojana, and the Maharashtra government has implemented these schemes. The Pune district has been identified as an Agri Export Zone for grape and grape wine, pomegranate, and onion. The Maharashtra Industrial Development Corporation has established a floriculture park at Talegaon, Pune (Kulkarni 2012).

The Indian Council of Agricultural Research (ICAR), under the Ministry of Agriculture and Farmers Welfare, set up the ICAR-National Research Centre for Grapes, Directorate of Onion and Garlic Research, ICAR-Directorate of Floricultural Research, and ICAR-National Research Centre on Pomegranate to conduct research on these crops and provide farmers support and extension services.

The Maharashtra State Agricultural Marketing Board has established a horticulture training centre, at Talegaon Dabhade, that focuses on floriculture and trains farmers in greenhouse/polyhouse management. Numerous public and private nurseries have been established that meet the requirement of planting materials in both protected and open field conditions.

Horticulture crops are capital-intensive and subsidized by the government. It is important to show empirically to farmers that protected cultivation of horticulture crops can be profitable. This study assesses the impact of protected cultivation, and the level of factors in, and constraints to adoption.

Data and sampling framework

We conducted the study in 2018–19 using both primary and secondary data. The National Horticulture Mission supports protected cultivation; we collected the secondary data on structures and the area from the Ministry of Agriculture and Farmers Welfare, Government of India.

We conducted a pilot survey and set up two focus groups (N = 12 per group) in the Pune and Nasik districts of Maharashtra, where farmers practise protected cultivation on 18% of the cultivable area in the state. Most farmers who practise protected cultivation grow rose, gerbera, carnation, and capsicum. We conducted an initial assessment and then a primary survey, using the multistage stratified sampling technique to select the farmers for the study.

At the first stage, we purposively selected Nasik and Pune based on the number of polyhouses and shade net houses. At the second stage, we selected purposively from each district 2 major blocks that practise protected cultivation.

At the third stage, we purposively chose from each block 2 clusters of villages, each comprising 2–3 villages that practise protected cultivation. At the final stage, from 8 clusters of villages, we randomly selected farmers that practise protected cultivation.

For the purpose of comparison, we randomly selected from the same cluster of villages 42 farmers practising open cultivation. We interviewed these farmers using a primary survey schedule and collected data on socioeconomic characteristics, technology adoption, cost of establishment of protected cultivation, cost of cultivation and returns, and constraints to adoption.

Methodology

We computed a composite technology adoption index (CTAI) (Manaswi et al. 2019) to measure the extent of the adoption of the technologies recommended:

$$CTAI_i = \sum_{j=1}^{18} w_{ij} x_{ij} \qquad \ldots(1)$$

where,

$CTAI_i$ is the composite technology adoption index,

w_j is the weight assigned to each technology adopted by the farmers under protected cultivation,

x_j is the adoption of recommended technologies.

w_j is the weight assigned to i and calculated through principal component analysis (PCA).

If the farmers had followed a recommended technology, the score is 1; if they had not adopted any, the score is 0.

We selected the maximum eigenvalue in any of the principal components for a given technology and computed its squared value. We computed the weighted eigenvalues using the variance explained by the respective principal component from which the maximum eigenvalue was drawn for a particular technology. We standardized these weighted eigenvalues to make the sum equal to 1. The standard eigenvalue became the weight for a given technology.

The farmers adopted several technologies; plant-to-plant spacing (0.091) and row-to-row distance (0.090) recorded the maximum weights and organic formulations (0.013) the least (Appendix Table 1).

We conducted a farm business analysis to estimate the costs and returns of crops under protected cultivation and under open cultivation. We computed the gross returns by multiplying the total production of flowers and vegetables with the respective prices received. We calculated the net returns by subtracting the annual total costs from gross returns.

The equation is

$$\pi = GR_i - TC_i \quad \ldots(2)$$

where,

π is the net returns,

GR is the gross returns, and

TC is the total costs.

We used the Tobit model to identify the influences on a farmer's decision to adopt. The advantage of the Tobit model is that it measures both the probability and intensity of adoption (Adesina and Zinnah 1993; Shiyani et al. 2002).

The Tobit model can be described in terms of the latent variable $CTAI_i$*. Suppose $CTAI_i$* is observed when $CTAI_i^* > T$ and is not observed when $CTAI_i$*d"T (Amemiya 1985; Maddala 1992; Adesina and Zinnah 1993). So, the observed $CTAI_i$ model is

$$CTAI_i = X_i\beta \text{ if } CTAI^* = X_i b + u_i > T$$
$$= 0 \text{ if } CTAI^* = X_i b + u_i \leq T \quad \ldots(3)$$

where,

CTAI* is the adoption index of i[th] farmer,

X_i is the vector of factors affecting adoption,

β is the vector parameters to be estimated,

u_i is an independently normally distributed error term with zero mean and constant variance σ^2.

Equation 3 is a simultaneous and stochastic decision model. If the non-observed latent variable CTAI* is greater than T, the adoption index becomes a continuous function of the explanatory variables; otherwise, it is 0 (that is, the farmer does not adopt the technology). We use the maximum likelihood approach to estimate the coefficients in Equation 3; Table 1 presents the explanatory variables.

Results and discussion

The central and state governments implement several schemes to promote and develop protected cultivation. The National Horticulture Mission offers a 50% subsidy for setting up protected cultivation structures and for purchasing planting materials of vegetables and flowers for cultivation in polyhouses / shade net houses.

Area under protected cultivation

The National Horticulture Mission had targeted to expand the practice of protected cultivation to an area of 11,631 ha in Maharashtra in 2017–18, but it expanded the practice to 16,024 ha, over 138% of the target. Protected cultivation comprises a variety of components; plastic mulching occupied 64.68% of the area, shade net houses 17.14%, and naturally ventilated polyhouses 10.23% (Table 2).

Table 1 Definition of variables used in the Tobit model

Variables	Unit of measurement	Expected sign
Dependent variable	Technology adoption index (TAI)	
Age	Age of household head (years)	+
Education	Number of years of formal education of farmer	+
Farm size	Size of the land owned by household (ha)	+
Ln_ income	Average household annual income (INR)	+
Loan	1 if the farmer has access to credit; 0 otherwise	±
Subsidy	1 if the farmer has access to subsidy; 0 otherwise	+
Market distance	Distance of farm from market (km)	-
Area	Area under protected cultivation (%)	+
Experience	Experience in protected cultivation farming (years)	+

Household characteristics of protected cultivation farmers

Table 3 depicts the socio-economic characteristics of farmers practising protected cultivation in Maharashtra. The survey sample is 116; about 75% of the farmers were young, indicating that young farmers adopt new technology faster than others. All the adopter farmers were literate; their awareness of the technology might

Table 2 Protected cultivation under National Horticulture Mission in Maharashtra

Protected cultivation	Total area (ha)	Share (%)
Greenhouse structure (fan and pad system)	40.6	0.25
Naturally ventilated polyhouse	1,639.15	10.23
Shade net house	2,746.99	17.14
Plastic tunnel	51	0.32
Anti-bird / anti-hail nets	219	1.37
Planting material of high-value vegetables grown in polyhouse	340.63	2.13
Planting material for flowers for polyhouse / shade net	623.28	3.89
Plastic mulching	10,364.23	64.68
Total	16,024.88	100

Source National Horticulture Mission (2005–06 to 2017–18)

Table 3 Farmers' socio-economic characteristics (N = 116)

Particulars	Classification	Percentage of sample farmers
Age (years)	Younger than 30 years	9.2
	30–45 years	71.7
	Older than 45 years	19.2
Education	Illiterate	0.0
	Primary	0.8
	High school	30.8
	Intermediate	41.7
	Graduate and above	26.7
Farming experience (Experience (years)	Less than 2	9.2
	2–5	35.8
	5–10	37.5
	More than 10	17.5
Number of polyhouses owned	Less than 1	86.7
	1–2	13.3
Occupation	Farmer	91.67
	Business/service	5.83
	Government	0.83
	LIC agent	1.67
Landholding size (ha)	Marginal farmers (<1)	50.0
	Small farmers (1–2)	40.0
	Medium farmers (2–10)	10.0
Area under protected cultivation (m^2)	Less than 1,000	53.3
	1,000–2,000	27.2
	2000–3,000	0.8
	3,000–4,000	15.8
	More than 4,000	0.8

Source Authors' calculations based on field survey (2018) have facilitated adoption. About 41.7% of the farmers were educated up to the intermediate level and 30.8% up to high school; 26.7% had a college or university degree, indicating that practising protected cultivation was more remunerative than working at a job.

Farming experience positively influences productivity. The technology of protected cultivation is new in India; and about 35% of the farmers had 2–5 years of experience, 38% had 5–10 years, and 17% had more than 10 years of experience. About 87% of the farmers had 1 polyhouse and the rest had 2 polyhouses. Farming was the major occupation of 92% of the sample households; 5.83% were in business or salaried employment, 1.67% worked as agents of the Life Insurance Corporation (LIC), and 0.83% were employed by the government. This breaks the myth that capital-intensive technology, like protected cultivation, favours farmers; businesspeople and salaried employees, too, can practise it.

About 50% of the farmers were marginal farmers and 40% were small farmers. From these findings, it can be concluded that the technology is scale-neutral and it can be adopted for doubling farmers' income.

Most farmers (53.3%) practised protected cultivation over an area of less than 1,000 square metre (sq m), 28.3% over 1,000–2,000 sq m, 15.8% over 3,000–4,000 sq m, and 1.7% of the farmers had more than 4,000 m^2. Nearly 50% of farmers practised protected cultivation over an area of only 1,000 m^2 because they had little experience; they may expand their practice as they gain experience.

Level of adoption

Table 4 presents the frequency of farmers adopting each technology under protected cultivation. The technology adopted by the sample farmers is given a score of 1; if a technology is not adopted, it is given a score of 0.

All the farmers (100%) adopted drip irrigation and fertigation. Over 80% of the farmers used improved varieties, soil testing, and packaging. Most of the farmers practised using insect nets (78%), staking and supporting (74%), curtain-opening (71%), double-door system (66%), plant-to-plant spacing (63%), row-to-row distancing (61%), proper harvesting (53%), pruning (51%), and bed preparation (44%). However, adoption was low for practices such as organic formulation (41%), timely planting (35%), plastic mulching (37%), soil solarization (35%), and crop rotation (34%); only 2% of farmers raised a nursery and others procured planting materials from private and government companies.

Table 4 Sample farmers' adoption of protected cultivation technologies

Protected technologies	Number	Frequency of adopters (%)
Drip irrigation	116	100
Fertigation	116	100
Double door system	76	65.52
Plastic mulching	43	37.07
Curtain opening	82	70.69
Insect nets	90	77.59
Use of improved variety	106	91.38
Nursery raising	2	1.72
Bed preparation	51	43.97
Crop rotation	40	34.48
Soil solarization	41	35.34
Soil testing	104	89.66
Organic formulations	47	40.52
Maintain row-to-row distance	71	61.21
Plant to plant spacing	73	62.93
Timely planting	46	35.34
Deshooting and pruning	59	50.86
Staking and supporting	43	74.14
Harvesting method/time	62	53.45
Packaging	101	87.07

Source Authors' calculations based on field survey (2018)

We used PCA to calculate the weights for each technology adopted and calculated the CTAI on the basis of the weight obtained for each technology for each farmer (Table 5). The TAI ranges between 0.23 and 0.91. Most farmers (51%) were in the medium adoption class. The adoption index ranged between 0.40–0.60. About 40% were in the category of high adopters (CTAI > 0.60). Dupare et al. (2011), Singh et al. (2013), and Sharma et al. (2018) have also reported similar results.

Establishment cost of protected cultivation by crop

The total cost of establishing a polyhouse (0.1 ha) under protected cultivation was INR 16.15 lakhs for rose,

Table 5 Farmers ranked on the composite technology adoption index (CTAI)

Farmer category	CTAI range	Number	Percentage of farmers
Low adopter	<0.40	10	8.62
Medium adopter	0.40–0.60	59	50.86
High adopter	>0.60	47	40.51

Source Authors' calculations based on field survey (2018)

INR 13.79 lakhs for gerbera, INR 12.99 lakhs for carnations, and INR 10.06 lakhs for capsicum (Table 6).

The polyhouse structure constituted the most important component of the establishment cost: about 84% for capsicum, 80% for rose, 72% for gerbera, and 66% for carnations. The crop establishment cost was high for carnation (INR 3.12 lakhs, 24%), gerbera (INR 2.60 lakhs, 18.88%), rose (INR 1.4 lakhs, 9.03%), and capsicum (INR 0.32 lakhs, 3.26%). The subsidy amount to the total establishment cost was INR 7.19 lakhs for rose, INR 5.98 lakhs for carnation, INR 5.76 lakhs for gerbera, and INR 4.77 lakhs for capsicum.

Costs and returns under protected cultivation by crop

The total annual cost of cultivation under polyhouse (0.1 ha) worked out to INR 4.61 lakh for carnation, INR 4.60 lakh for gerbera, INR 4.49 lakh for rose, and INR 3.15 lakh for capsicum (Table 7). The increase in the cost of cultivating carnation and gerbera may be due to the high cost of planting materials.

The net income from protected cultivation (0.1 ha) was INR 2.22 lakh for carnation, INR 1.64 lakh for rose, INR 1.63 lakh for gerbera, and INR 1.04 lakh for capsicum. The benefit–cost ratio—greater than 1 for all crops, indicating that protected cultivation is profitable—is 1.48 for carnation, 1.37 for rose, 1.36 for gerbera, and 1.33 for capsicum.

Table 6 Cost of establishing protected cultivation by crop (0.1 ha)

Crop	Polyhouse structure		Irrigation system		Crop establishment		Total establishment cost	Subsidy		Establishment cost minus subsidy
	INR in Lakhs	Share in total cost	INR in Lakhs	Share in total cost	INR (lakh)	Share in total cost	INR in Lakhs	INR (lakh)	Share in total cost	INR (lakh)
Rose	12.97	80.26	1.73	10.71	1.46	9.03	16.15	7.19	44.47	8.97
Carnation	8.62	66.30	1.25	9.62	3.13	24.08	12.99	5.98	45.98	7.02
Gerbera	9.97	72.24	1.23	8.88	2.60	18.88	13.79	5.76	41.71	8.04
Capsicum	8.47	84.17	1.26	12.57	0.33	3.26	10.06	4.77	47.38	5.29

Source Authors' calculations based on field survey (2018)

Table 7 Costs and returns under protected cultivation by crop (0.1 ha)

Crop	Cost of cultivation				Total cost	Income		Benefit cost ratio
	Fixed costs		Variable costs			Total income	Net income	
	INR (lakh)	Share in total cost	INR (lakh)	Share in total cost	INR (lakh)	INR (lakh)	INR (lakh)	
Rose	2.06	45.76	2.44	54.24	4.49	6.14	1.64	1.48
Carnation	2.30	49.96	2.31	50.04	4.61	6.83	2.22	1.36
Gerbera	2.26	49.23	2.33	50.77	4.60	6.23	1.63	1.33
Capsicum	1.37	43.43	1.78	56.57	3.15	4.19	1.04	1.37

Source Authors' calculations based on field survey (2018)

Table 8 Costs# and returns of rose cultivation under protected cultivation and under open cultivation

Particulars	Protected		Increase over open method of cultivation (%)	Open	
	Value	Percentage of total		Value	Percentage of total
Total fixed cost (INR lakh per acre)	6.83	52.92		0.47	15.54
Total variable cost (INR lakh per acre)	6.07	47.08		2.55	84.46
Total cost (INR lakh per acre)	12.91	100		3.01	100
Production (number in lakh per acre)	7.80		130	3.48	
Sale price (INR per flower)	3.0		53	1.96	
Gross return (lakh INR per acre)	23.99		252	6.81	
Net return (lakh INR per acre)	11.09		192	3.80	

Note #- one year growing period of rose considered for protected and open cultivation as well

Costs and returns of producing roses under protected cultivation and under open cultivation

We analyse the costs of and returns from producing roses under protected cultivation and open cultivation and compare the two (Table 8). Protected cultivation requires a larger investment, and it costs about INR 12.91 lakh per acre per annum, much more than the INR 3.01 lakh needed for open cultivation; 47% of the cost of protected cultivation is incurred for variable costs, much less than the 84% for open cultivation. But the yield under protected cultivation is 130% of open cultivation; the price per flower averages INR 3 under protected cultivation and INR 2 under open cultivation; the gross returns are 252% of that under open cultivation and the net returns 192%.

Costs and returns of producing roses under protected cultivation and under open cultivation

We analyse the costs of and returns from producing capsicum under protected cultivation and open cultivation and compare the two (Table 9).

The annual cost of protected cultivation of capsicum was INR 3.85 lakh per acre per annum, much higher than for open cultivation. The variable costs constituted 74% of the annual cost of protected cultivation and 88% of open cultivation. The yield of protected cultivation was 137% of that of open cultivation. Capsicum produced under protected conditions sold at nearly 300% of capsicum grown under open cultivation; the gross return was 600% and net return 594%.

Factors influencing adoption

We analyse the influences on the adoption of protected cultivation using the Tobit regression model and the technology adoption index (TAI) as the dependent variable (Table 10).

Table 9 Costs# and returns of capsicum cultivation under cultivation and under open cultivation

Particulars	Protected		Increase over open method of cultivation (%)	Open	
	Value	Percentage of total		Value	Percentage of total
Total fixed cost (lakh INR per acre)	1.0	25.95		0.07	12.05
Total variable cost (lakh INR per acre)	2.85	74.05		0.48	87.95
Total cost (lakh INR per acre)	3.85	100		0.54	100
Production (kg per acre)	14,800		137	0.06	
Sale price (INR per kg)	41.5		196	14	
Gross return (lakh INR per acre)	6.14		600	0.87	
Net return (lakh INR per acre)	2.29		594	0.33	

Note #- four month growing period of capsicum considered for protected and open cultivation as well

Table 10 Estimated parameters of Tobit model

Parameter	Estimates of Tobit model		
	Coefficients	Std error	t value
Age (years)	0.0029*	0.0017	1.68
Education (years)	0.0145**	0.0056	2.59
Farm size (ha)	0.0257*	0.0150	1.71
Loan (1=yes, 0=otherwise)	"0.0255	0.0288	–0.88
Subsidy (1=yes, 0=otherwise)	0.0433	0.0424	1.02
Ln_Income (INR)	0.0454**	0.0214	2.12
Distance from market (km)	–0.0009*	0.0005	–1.90
% area under protected cultivation	–0.0006	0.0015	–0.44
Experience in protected farming (years)	–0.0006	0.0030	–0.22
Constant	–0.3214	0.2940	–1.09
_Sigma	0.0142***	0.0018	7.61
Log likelihood	81.32		
Prob> chi^2	0.019		
Pseudo R^2	–0.138		
Number of observations	116		

Note ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

The Tobit model had a sigma value of 0.014, and it is statistically significant at 1% level of significance, indicating that the data was appropriate for the model. In computing the adoption index for the adopters, we censored the non-adopters among the adopters (on the left) and the farmers who have not adopted the recommended protected cultivation technologies (on the right). The adoption index ranges from 0.21 to 0.91.

It was reasonable to use the Tobit model; the results revealed that technology adoption is significantly influenced by age, education, household income, farm size, and distance from the market. Age had a significant and positive influence on the intensity of adoption, at 10% level of significance, indicating that the accumulation of wealth over time let more older farmers than younger ones adopt the technology. Ghimire et al. (2015) report a similar result.

The level of education has a positive and significant effect at 5% level of significance, implying that adoption was higher among better educated farmers. Other studies, too, report that education positively influences adoption (Kebede et al. 1990; Alene et al. 2000; Shiyani et al. 2002; Sharma et al. 2018).

Household income is found to be positive and significant at 5% level, implying that higher the family income, higher is the adoption. Sharma et al. (2018) confirm that household income was positively related to the adoption of new technologies.

The effect of landholding size is positive and significant, implying that adoption improves as large farmers generate more income and, in turn, improve their capital base and risk-bearing ability. Other studies, too, report that farm size positively influences adoption (Mendola 200; Kassie et al. 2011; Mariano et al. 2012).

The coefficient of distance from the market was significant at 10% level; it was negatively related with adoption, indicated that nearer the market, higher the adoption. Manaswi et al. (2019) report a similar result.

Constraints to the adoption of protected cultivation

We used Garrett's ranking technique to analyse the constraints to adoption (Table 11): constructing a polyhouse requires a high initial investment, planting materials are expensive, and the incidence of pests and diseases.

The Government of India has launched several schemes to promote protected cultivation such as the National Horticulture Mission, National Horticulture Board, and Horticulture Mission for North East Himalayan States.

Table 11 Constraints to the adoption of protected cultivation

Particulars	Mean Garrett's score	Rank
High initial investment in construction of polyhouse	93.67	1
High cost of planting material	87.00	2
High incidence of pests and diseases	83.42	3
Distance from market	77.00	4
High cost of transportation	75.00	5
High cost of plant protection chemicals	73.65	6
Poor price received	68.00	7
Lack of adequate and timely disbursement of loans	67.12	8
Non-availability of skilled labour	58.23	9
Lack of crop insurance	53.43	10
Difficulty in getting subsidy	59.76	11
High labour wages	42.27	12
Difficulty in getting credit	41.29	13
Lack of local technical expertise	38.00	14

Source Authors' calculations based on field survey (2018)

The National Horticulture Mission, the most important scheme in Maharashtra, provides a 50% subsidy for building a greenhouse structure and purchasing planting materials, but its access is limited to only a few farmers; its scope must be expanded to include more farmers and the subsidy amount enhanced. Farther the distance to markets, higher the expenditure that farmers incur on transporting their produce. Polyhouse cultivation is labour-intensive and it requires skilled labour, but farmers in the study area find that not enough skilled labour is available.

Reasons for discontinuing protected cultivation

Polyhouse cultivation entails higher risk than open cultivation, the prime reason farmers discontinue the practice. Natural calamities, and the lack of personal supervision, are the most important factors of higher risk. The incidence of pests and diseases, and poor knowledge of control measures, increase the cost of cultivation. Proper markets are few and far between, and products are not properly differentiated; therefore, the produce fetches low prices and profits.(Table 12). About 2% of the sample farmers abandoned polyhouse cultivation.

Table 12 Reasons for discontinuation of protected cultivation

Particulars	Rank
Higher risk	1
Lack of supervision	2
Natural calamities	3
Low price due to poor product differentiation	4
High incidence of pests and diseases	5
High maintenance cost	6
Subsidy on planting material/seed/fertilizer not available	7

Source Authors' calculations based on field survey (2018)

Conclusions and policy implications

The central and state governments have implemented several schemes to promote and develop protected cultivation. These interventions brought the area under protected cultivation in Maharashtra under the National Horticulture Mission to 16,000 ha. The CTAI ranges from 0.23 to 0.91, and most farmers were in the category of medium adopters (0.40–0.60). Most farmers adopted the micro-irrigation components of the protected cultivation technology. Adoption is significantly influenced by age, education, household income, landholding size, and distance from market.

The investment required for the protected cultivation of rose and capsicum is over 300% of that for open cultivation, and the gross returns are over 250% and net returns over 190%. However, farmers abandon the practice because polyhouse cultivation entails higher risk. To encourage adoption, therefore, the risk needs to be minimized and the capital subsidy for establishing protected cultivation needs to be continued to demonstrate its profitability and affordability to farmers.

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Appendix Table 1 Weights computed for various technologies under protected cultivation

Protected technologies	Weight	Protected technologies	Weight
Double door system	0.068	Soil testing	0.0662
Plastic mulching	0.041	Organic formulations	0.0136
Curtain opening	0.077	Maintain row-to-row distance	0.0906
Insect nets	0.058	Plant-to-plant spacing	0.0916
Use of improved variety	0.038	Timely planting	0.0394
Nursery raising	0.054	Deshooting and pruning	0.0572
Bed preparation	0.031	Staking and supporting	0.0403
Crop rotation	0.068	Harvesting method/time	0.0789
Soil solarization	0.033	Packaging	0.0548

Note All the farmers adopted drip irrigation and fertigation; therefore, we excluded . these technologies when running the PCA.