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SUBJECT III
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Polyhouse Technology for High-Value Crops: Variability in Practices and Outcome

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ABSTRACT

The protected cultivation technology holds special significance for hilly states like Himachal Pradesh where arable land is scarce due to uneven terrain and holdings are small and fragmented. A number of polyhouses has been constructed throughout the state under Pandit Deen Dayal Kisan Bagwan Samridhi Yojna (PDDKBSY). The scheme involved huge investments but has not yielded the expected and desirable results. Also the benefits could not be sustained for desirable period because of some technological gaps in the management of polyhouses. In order to examine these technological gaps, a study was conducted in two blocks of Kangra district of Himachal Pradesh. A sample of 60 polyhouse farmers (33 small and 27 large) was selected by proportional allocation method. Department of Agriculture was reported to be the major motivational force behind the adoption of technology by the farmers however only 38 per cent of the beneficiaries had genuine interest behind the installation of polyhouses. Eighty-five per cent of the beneficiaries were trained but all after the installation of polyhouses. The average area under protected cultivation was 110.45 m^2 on small category and 302.89 m^2 on large category. Capsicum accounted for maximum area (37.91%) followed by tomato (32.52 per cent) and cucumber (29.57 per cent). On an average, the productivity of cucumber was highest (9.99 q/100m^2) followed by tomato (7.12 q/100m^2). Gaps in the output of different crops varied from 26-36 per cent. More than 40 per cent of farmers were in low (< 40 per cent) technical efficiency range. The total cost of cultivation per 100 m^2 area on small farms was Rs. 13,939, 13,848 and 11,312, for capsicum, tomato and cucumber, respectively and on large farms it was Rs. 10,935, 10,672 and 8952, respectively. Net returns over variable costs were Rs. 21,800, 11,836 and 8,406 on small farms and Rs. 12,180, 7,754 and 6,524 on large farms for capsicum, tomato and cucumber, respectively. Significantly high gaps were observed in the management practices like seed and soil treatments, pinching/pruning, spacing and plant protection. The existing design and structure of sampled polyhouses was found to have yawning gaps w.r.t. site selection, shape and orientation of polyhouses, foundation security and quality of cladding material etc. Negative gaps were observed in case of the inputs, viz., seed, seedlings, composts, nitrogenous fertilisers, MOP and plant protection chemicals on different crops indicating excess use by average farmers. Thus, the gaps in yields of crops were contributed more by the faulty management practices, faulty construction/design of polyhouses and scant attention of farmers towards the precautionary measures. Some suggestions to ensure the success of protected cultivation are: selection of genuine farmers, prior training of the beneficiaries, proper construction of polyhouses and provision of efficient advisory services.

Keywords: Protected cultivation, technical efficiency, technological gaps

JEL: Q15, Q16, Q55

I

INTRODUCTION

Greenhouse vegetable production in India is a new approach and it has been identified as a potential means for higher production of vegetables and other horticultural crops. Protected cultivation technology has given growers a powerful

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management tool for production of high value commercial crops with high level of technology and adequate economic returns over investment.

The protected cultivation technology holds special significance for hilly states like Himachal Pradesh where arable land is scarce and holdings are small and fragmented. In Himachal Pradesh, only 12 per cent of the total geographical area of 55.7 lakh hectares is available for cultivation. About 86 per cent of the holdings are marginal and small and irrigated area is 17 per cent of the total cropped area. There is a great variation in agro-climatic conditions in the state which range from sub-humid sub-tropical to dry temperate zone. Due to extreme climatic conditions, such as long winter season, excessive heat, snow, etc., in different parts of the state, the cultivation of input sensitive and highly remunerative cash crops like vegetables becomes difficult.

Therefore, in the present scenario of shrinking land holdings, coupled with perceptible changes in weather and climate, protected cultivation has emerged as the best alternative for using land and other resources efficiently. The concept has enabled farmers to grow exotic vegetables and flowers throughout the year. However, there is urgent need to create more infra-structure for protected cultivation, marketing and value addition and to bridge the technological gaps at farm level.

The state government has made strenous efforts to encourage the farmers to adopt polyhouse technology by providing significant financial assistance under various schemes viz., Pandit Deen Dayal Kisan Bagwan Samridhi Yojna worth Rs. 155 crores and "Dr. Y.S. Parmar Kisan Swarozgar Yojna" worth Rs. 111.19 crore. Since, it is purely a commercial agri-business venture with substantial initial investment, it is very important to harness the facility to its full capacity and to obtain rich dividends. But, it has been observed that the polyhouse technology has not been able to yield the expected and desirable results. Some gaps in design, structure, construction, material, cropping systems, input-use and management practices being followed inside the polyhouses have been reported because of which the heavy investments made by the government as well as by farmers have failed to enhance the farm income to the expected level. Therefore, the present study was conducted to examine the technological gaps in the management of polyhouses so as to provide a much warranted feedback to the policy makers, implementing agencies, research and extension agencies to help them work in the direction to bridge the gaps and enhance the probability of this enviable project.

II

METHODOLOGY

The present study was conducted in two blocks, viz., Kangra and Dehra (having maximum number of polyhouses) of Kangra district in Himachal Pradesh. In all, there were about 255 polyhouses (excluding polytunnels and polyhouses<100 m^2) in the two blocks and about 25 per cent of these were included in the sample. A sample of 60 polyhouse growers was selected randomly through proportional allocation method. The polyhouse units were then post stratified into small (<250 m^2) and large (≥250 m^2) categories. Thus, a total of 33 small and 27 large polyhouse growers were selected. Primary data were collected through survey method from polyhouse owners.

The required secondary data were collected from the Directorate of Agriculture, Shimla (Himachal Pradesh), Office of the Deputy Director of Agriculture, Palampur, published/unpublished sources and official websites (http://www.hpagriculture.com, http://himachal.nic.in/economics).

Tabular analysis including computation of averages, percentages, ratios and indices etc. was extensively used to interpret the results. Some of the formulae used were as below.

Technical Efficiency:

A farmer is said to be technically efficient if he consistently produces larger quantities of output from the same quantities of measurable inputs.

Technical efficiency (Ti)=$(Y_i/Y_f)\times 100$

where, Ti = technical efficiency of i-th farmer; Yi = actual yield obtained by i-th farmer;

Y_f = yield obtained by frontier (progressive) grower in the study area

Based on the technical efficiency, the farmers were categorized as:

Low efficiency farmers: below 40 per cent; Medium efficiency farmers: between 40 per cent to 70 per cent; High efficiency farmers: above 70 per cent

Technological Gaps

Technological gaps were computed on the basis of difference between the management practices, design/structure of polyhouses and input usage on progressive/frontier farm and actual management practices, design/structure of polyhouse and input usage on an average farm. These were computed by using following algorithm:

(i) Technological gaps in input use (T_{gi})= $[(Y_f - Y_a)/ Y_f]\times 100$

where, T_{gi}= technological gap (per cent) in input usage; Y_f = input usage by frontier farmer;

Y_a = actual input usage by average farmer.

(ii) Technological gaps in management practices (T_{gm})=$[(F_t - F_p)/ F_t]\times 100$

where, T_{gm} = technological gap (per cent) in management practices; F_t = total number of farmers; F_p = number of farmers practicing frontier/recommended management practice.

(iii) Technological gaps in design/structure of polyhouse $(T_{gd}) = [(F_t - F_d)/ F_t] \times 100$

where, T_{gd} = technological gap (per cent) in design/structure of polyhouse; F_t = total number of farmers; F_d= number of farmers having recommended design/structure of polyhouse.

III

RESULTS

The success of crop cultivation under protected structures depended upon the accuracy with which these structures were constructed, proper selection of site, direction and design suitable for a particular location and most importantly the need, interest and technical know-how of the farmer. The analysis of motivation and interest factors, training level of farmers and construction companies involved has been presented in section below.

Average Size of Polyhouse and Mode of Construction

Different size/types of polyhouses have been constructed under PDDKBSY. Overall average area under polyhpuses was 197.05m^2/farm in the study area. Large sized polyhouses had an average area of 302.89 m^2 while small farms owned polyhouse area of 110.45 m^2. Most of these units were constructed by specialised firms (93.33 per cent) viz., Jain Irrigation (61.67), Shiwalik (21.66) and Complete Solutions (10.00) etc., while the self-constructed polyhouses were only 6.67 per cent of the total polyhouses.

Motivational and Interest Factors

Polyhouse technology is a new and advanced technology and for its effective adoption, farmers had to be motivated and convinced. It was found that Agriculture Department had played a significant role in motivation process. About 48 per cent of small and 59 per cent of large farmers were motivated by the Department of Agriculture. About 20 per cent of the farmers reported motivation by Agricultual University. Electronic/print media also acted as a major motivational factor for adoption of polyhouse technology for about 17 per cent of the sampled farmers while 10 per cent were inspired by their neighbours or friends. Motive with which the farmer got a polyhouse installed, interest taken by him in its management and its importance as a source of income for the farmer, were the key factors for success of a polyhouse. It was observed that only 38 per cent of the polyhouse owners were genuinely interested for installation of polyhouse and tried their level best to make it a success. About 40 per cent farmers got the polyhouses installed at their farms just to take advantage of high subsidy as no/very less personal investment was involved. The department officials had to fulfill their targets within a given time frame, so, they sometimes convinced/lured the farmers on the pretext of pesticide free cultivation inside polyhouses and premium prices for polyhouse produce which practically could not be realised because of faulty construction of polyhouses and lack of training among farmers.

Training of Farmers

There is no denying the fact that cultivation under protected conditions require proper training of the farmers to improve their skills and realize the maximum efficiency. Around 85 per cent of the respondents were trained in protected cultivation. The respondents had acquired trainings on production, management and marketing aspects. About 76 per cent of the respondents had acquired one training and 20 per cent had two and only 4 per cent had three or more than three trainings. But, almost all the farmers got their trainings after the installation of their polyhouses and had no knowledge about the suitable site, orientation, structure, design and construction of polyhouse at the time of installation. So, for better management of the polyhouses, more effective trainings should be imparted before the installation of polyhouses.

Cropping Pattern

The total cropped area per farm under protected cultivation was estimated to be 192.95 m^2 (Table 1). Maximum cropped area was found to be under capsicum (37.91 per cent) followed by tomato (32.52 per cent) and cucumber (29.57 per cent). Total cropped area under protected cultivation on large farms was 300.44 m^2 while that on small units was 105.00 m^2. Capsicum was the predominant crop on both the categories of farms which might be mainly due to more suitability of the crop in the study area. The cropping intensity was worked out to be 100 per cent because only one crop was being cultivated during the year.

TABLE 1: CROPPING PATTERN UNDER POLYHOUSE CULTIVATION

(*per cent)*

Crops (1)	Small farms (2)	Large farms (3)	Overall farms (4)
Capsicum	39.39	37.28	37.91
Tomato	27.28	34.76	32.52
Cucumber	33.33	27.96	29.57
Gross cultivated area	100.00 (105.00)	100.00 (300.44)	100.00 (192.95)
Cropping intensity (per cent)	100.00	100.00	100.00

Note: Figures in parentheses represent the total area in m2

Production and Productivity Under Protected Cultivation

Among different crops grown, cucumber gave the highest yield (10 q/100m^2) followed by tomato and capsicum (Table 2). In general, the productivity on small units was higher for all crops except cucumber. This might be due to slightly better management on small units as compared to the large units. Pandey *et al*. (2005) reported high productivity of capsicum under polyhouse due to favourable growing conditions and better utilization of vertical space.

TABLE 2: PRODUCTION AND PRODUCTIVITY OF DIFFERENT CROPS UNDER POLYHOUSE CULTIVATION

Crops	Small farms		Large farms		Overall farms	
	Production (q/farm)	Productivity (q/100 m^2)	Production (q/farm)	Productivity (q/100 m^2)	Production (q/farm)	Productivity (q/100 m^2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Capsicum	3.70	8.95	6.44	5.75	4.93	6.74
Tomato	2.55	8.90	6.81	6.52	4.47	7.12
Cucumber	4.03	11.51	7.74	9.21	5.70	9.99

Technical Efficiency and Technological Gaps

The economic viability/efficiency of protected cultivation depends upon efficient use of inputs in right combinations to maximize the yield per unit of time and space. It was observed that the actual output realised by an average farm was less than the frontier (maximum attainable) level of output. There were few progressive farmers in the area who used the frontier level of technology and could either produce higher level of output with the same quantity of inputs or same level of output with the lower level of inputs (Palanisami *et al*,.2002). In both the situations, there were either high returns or cost saving with frontier technology. Obviously, the differences in yields and costs accrued mainly due to the differences either in management practices, input-use or design/ structure and inside features of the polyhouses. The extent of technological gaps with respect to different aspects of protected cultivation was studied and has been discussed in the section below.

Technical Efficiency

Technical efficiency was worked out on the basis of the difference between the yields obtained by average farmers and those obtained by the frontier farmers. The farmers growing all the three crops were grouped into three categories viz., low, medium and high in accordance to the technical efficiency obtained by them. As is evident from Table 3, majority of the farmers in both the categories were in medium range of technical efficiency varying from about 44 to 73 per cent on the small and 50 to 62.5 per cent of respondents on the large farms. About 38-40 per cent farmers growing capsicum in both the categories were in low technical efficiency range and only 10-15 per cent could qualify for high technical efficiency range. Similar was the case for tomato and cucumber indicating that considerable gaps existed in the yields of average farmers when compared with those realized by frontier farmers. Sharma (2012) also revealed that there were wide gaps in the yields of different crops in polyhouses. She reported that around 40-60 per cent growers of small category and 20-60 per cent growers of large category were in the medium range of technical efficiency.

TABLE 3: TECHNICAL EFFICIENCY RATING OF POLYHOUSE FARMERS

(per cent respondents)

Technical efficiency rating	Small Farms			Large Farms		
	Capsicum	Tomato	Cucumber	Capsicum	Tomato	Cucumber
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Low (< 40 per cent)	38.46	44.44	18.18	40.00	25.00	22.22
Medium (40-70 per cent)	46.15	44.44	72.73	50.00	62.50	55.56
High (>70 per cent)	15.39	11.12	9.09	10.00	12.50	22.22
Total	100.00 (13)	100.00 (9)	100.00 (11)	100.00 (10)	100.00 (8)	100.00 (9)

Note: Figures in parentheses indicate total number of farmers growing specified crops.

Costs and Returns

The variable cost of cultivation per 100 m^2 area on small farms turned out to be Rs. 9,525, 10,414 and 8,859 for capsicum, tomato and cucumber, respectively while that on large farms was Rs. 7,945, 8,546 and 7,291, respectively. Fixed costs were computed on the basis of growers' share in total investment and these were highest for capsicum followed by tomato and cucumber according to the duration of different crops which was nine, seven and five months, respectively. The total cost of cultivation per 100 m^2 area on small farms was Rs. 13,939, 13,848 and 11,312, for capsicum, tomato and cucumber, respectively and on large farms it was Rs. 10,935, 10,672 and 8952, respectively. Net returns over variable costs were Rs. 21,800, Rs. 11,836 and Rs. 8,406 on small farms and Rs. 12,180, Rs. 7,754 and Rs. 6,524 on large farms for capsicum, tomato and cucumber, respectively. The net returns on small farms were comparatively more which showed that the smaller farms were comparatively better managed. It is important to mention here that the net returns on both the categories of polyhouses were much higher than those obtained under open field conditions from all the crops. Output-input ratio of 2.25 was obtained for capsicum followed by tomato and cucumber on small farms which also indicated the comparative profitability of the crops. Sharma and Pathania (2010) also reported high returns from coloured capsicum due to remunerative prices obtained for it. Kaur (2009) reported the benefit-cost ratio for capsicum and tomato under open field conditions to be 1.34 and 1.72, respectively.

Technological Gaps in Management Practices

Proper management practices are the basis for efficient use of resources and higher productivity with better quality of produce. The management practices being followed by sampled polyhouse farmers have been presented in Table 4. The table reveals that all farmers on both the categories used hybrid seed for all the three crops grown by them in the polyhouses. But none of the farmers was practicing soil and seed treatment against the soil and seed borne diseases/pests. Majority of small farmers growing capsicum and tomato planted the crops at 50×30 cm spacing followed by a spacing of 60×30 cm. On large farms, a spacing of 60×30 cm was being followed by maximum proportion of the farmers for all the three crops. Narrow spacing of 50×30 cm was being followed by 40, 25 and 22 per cent of the large farmers on capsicum, tomato and cucumber, respectively.

TABLE 4: MANAGEMENT PRACTICES FOLLOWED UNDER POLYHOUSE CULTIVATION

(*per cent farmers*)

Sr. No	Particulars	Capsicum		Tomato		Cucumber	
		Small	Large	Small	Large	Small	Large
(1).	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Seed used, hybrid	100.00	100.00	100.00	100.00	100.00	100.00
2.	Soil/seed treatment	0.00	0.00	0.00	0.00	0.00	0.00
3.	Branches (number), two	15.38	0.00	33.33	62.50	54.55	44.44
	Three	30.78	30.00	44.44	25.00	27.27	55.56
	Four	38.46	50.00	22.23	12.50	0.00	0.00
	> Four	15.38	20.00	0.00	0.00	18.18	0.00
4.	Number of pruning/pinching, two times	30.77	20.00	33.33	12.50	72.73	66.67
	Four times	53.85	50.00	55.56	50.00	27.27	33.33
	Six times	15.38	30.00	11.11	37.50	0.00	0.00
5.	Spacing (cm) (R-R *P-P), 40*30	7.69	10.00	11.11	0.00	9.09	0.00
	50*30	46.15	40.00	44.44	25.00	36.36	22.22
	60*30	30.78	40.00	33.34	37.50	45.46	44.45
	70*30	15.38	10.00	11.11	37.50	9.09	33.33
6.	Number of weedings, two times	15.39	20.00	33.33	37.50	54.55	66.47
	Three times	38.46	40.00	44.44	25.00	36.36	33.53
	Four times	38.46	30.00	22.23	37.50	9.09	0.00
	> Four	7.69	10.00	0.00	0.00	0.00	0.00
7.	Irrigation/fertigation (No.), ≤ 40	0.00	0.00	0.00	0.00	9.09	11.11
	41-50	0.00	0.00	0.00	25.00	36.36	33.33
	51-70	38.46	20.00	44.44	50.00	54.55	55.56
	71-80	46.15	50.00	55.56	25.00	0.00	0.00
	>80	15.39	30.00	0.00	0.00	0.00	0.00
8.	Fungicide spray, two times	38.46	90.00	33.33	75.00	36.36	77.78
	> Two times	61.54	10.00	66.67	25.00	63.64	22.22
9.	Insecticide spray, two times	7.69	0.00	22.22	25.00	36.37	77.78
	Three times	38.46	50.00	11.11	12.50	45.45	22.22
	Four times	30.77	30.00	22.22	12.50	18.18	0.00
	Five times	23.08	10.00	33.34	37.50	0.00	0.00
	> Five times	0.00	10.00	11.11	12.50	0.00	0.00

For capsicum and tomato, most of the farmers on both the categories performed pruning/pinching operation for four times while for cucumber, the operation was performed only for two times by majority of the farmers. The proportion of farmers keeping four branches in capsicum was highest followed by those retaining three branches. In tomato, majority of the small farmers kept three branches but large farmers kept only two branches. Usually 2-4 weedings were being performed on different crops by the farmers in both the categories. In capsicum, majority of the farmers used to perform three weedings and in cucumber two weedings were being performed by most of the farmers. Sharma (2012) observed the wider adoption of management practices in polyhouses of Mandi district particularly with respect to training, pruning, spacing and use of fertilisers.

In capsicum, about 46 per cent small and 50 per cent large farmers practiced irrigation/fertigation for 71-80 times. The corresponding proportion for tomato was 56 and 25 per cent. In cucumber, about 56 per cent of the farmers provided irrigation/fertigation for 51-70 times. About 33-38 per cent of small farmers and 75-90 per cent large farmers applied fungicides in their crops for two times and rest of the farmers resorted for more than two fungicide sprays. In addition, the farmers used to practice 2-5 pesticide sprays on capsicum and tomato crops and 2-3 sprays on cucumber for pest control. The faulty practice observed among the farmers was that they applied the fungicides, pesticides and insecticides separately even when those could be combined. This increased their labour and energy costs. It can be concluded from the above discussion that the objective of pesticide free crop production inside the polyhouses could not be met. However, the number of pesticide sprays inside polyhouses was comparatively less than the open field conditions where the farmers were reported to spray tomato and capsicum crops for as many as 12-15 times.

Technological gaps with respect to management practices have been highlighted in Table 5. A perusal of the table reveals that in spacing, a technological gap of about 69, 67 and 55 per cent was observed for capsicum, tomato and cucumber, respectively. On large farms, the gap in spacing was highest (62.5 per cent) for tomato followed by capsicum (60 per cent) and cucumber (55.6 per cent). Majority of the farmers practiced narrower spacing than the recommended/frontier. None of the farmers was practicing soil and seed treatment showing 100 per cent gap. All the farmers on both the categories of farms were opting for hybrid seed as per recommendation. However, the gaps with respect to the selection of varieties were found to exist in all the crops. Practice of retaining four branches in capsicum and two branches in tomato and cucumber was being practiced by frontier farmers. It was observed that on small farms, a gap of about 62, 67 and 45 per cent, respectively was found on average farms in capsicum, tomato and cucumber. While the gaps on large farms were worked out to be 50, 37.5 and 55.6 per cent, respectively. Farmers, in general used to retain more branches than recommended/frontier. For pruning/pinching, a gap of 73 to 89 per cent and for weeding 62 to 78 per cent was observed for different crops on small farms. As high as 70-80 numbers of irrigations/fertigations were being applied by frontier farmer for capsicum, 50-70 for tomato and 40-50 for cucumber. Thus, a gap of 54 to 64 per cent on small farms and

50-67 per cent on large farms was observed for this operation. For plant protection sprays, a gap of 62 to 69 per cent was found to exist on small farms. The large farmers were observed to be close to the frontier/recommended practice of fungicidal spray hence reporting only 10-25 per cent gap.

TABLE 5: TECHNOLOGICAL GAPS IN MANAGEMENT PRACTICES

(*per cent*)

Sr. No.	Frontier practice	Small Farms			Large Farms		
		Technological gap			Technological gap		
(1)	(2)	Capsicum (3)	Tomato (4)	Cucumber (5)	Capsicum (6)	Tomato (7)	Cucumber (8)
1.	Spacing, 60*30	69.23	66.67	54.55	60.00	62.50	55.56
2.	Soil and seed treatment	100.00	100.0	100.00	100.00	100.00	100.00
3.	Seed variety, hybrid	0.00	0.00	0.00	0.00	0.00	0.00
4.	Number of branches, two	-	66.67	45.45	-	37.50	55.56
	Four	61.54	-	-	50.00	-	-
6.	Pinching/pruning, four times	-	-	72.73	-	-	66.67
	Six times	84.62	88.89	-	70.00	62.50	-
7.	Weeding, three times	-	-	63.64	-	-	66.67
	Four times	61.54	77.78	-	70.00	62.50	-
8.	Irrigation/fertigation (No.), 40-50	-	-	63.64	-	-	66.67
	50-70	-	55.56	-	-	50.00	-
	70-80	53.85	-	-	50.00	-	-
9.	Fungicide spray, two times	61.54	66.67	63.64	10.00	25.00	22.22
10.	Insecticide spray, two times	-	-	63.64	-	-	22.22
	Four times	69.23	-	-	70.00	-	-
	Five times	-	66.67	-	-	62.50	-
11.	Waiting period after last spray, 8-10 days	76.92	77.78	63.64	70.00	75.00	66.67

Technological Gaps in Design and Structure of Polyhouses

Technological gaps w.r.t. design and structure of polyhouses have been portrayed in Table 6. Proper selection of site was one of the most important factors to be considered before installation of a polyhouse. The place selected for a polyhouse should have a proper slope so that the run off of rainwater stays away from the polyhouse. Also the site should have proper sunlight. It can be observed from the table that only 27 polyhouses out of 60 were installed at proper site, thus presenting a gap of 55 per cent. Similarly, the orientation of polyhouse should be such that the strong winds are not able to damage it. The foundation of polyhouse is also needed to be well fixed and secured so that the strong winds or heavy rains are not able to uproot it. This gap was observed in case of about 68 per cent of the polyhouses and orientation was also found to be wrong for 40 per cent polyhouses.

The thickness of polyfilm used as cladding material and strength of frames used for structure of polyhouse were not found to be as per recommendation in about 42 and 25 per cent of the polyhouses, respectively. Nair and Barche (2014) also reported that the profile used in the polyhouse frame, trusses and other material was too light which easily got deformed by strong winds. Provision of double door entry was made in majority of the polyhouses but the angle between two doors, which was more important factor to check pest entry, was not right in about 70 per cent of the polyhouses. No gaps were observed w.r.t. the installation of fogger/drip irrigation system, top/side ventilation and top/side rolling shade nets inside polyhouses, however, the use of these facilities was not proper by majority of the farmers because of lack of technical know-how and proper training. Lack of knowledge and awareness on the part of beneficiary farmers about the basic instructions to be considered prior to the installation of polyhouses and careless approach of the construction companies was the major factor responsible for faulty construction of polyhouses. These gaps contributed a lot towards the damage/failure of the polyhouses and resulted even in their abandonment in some of the cases.

TABLE 6: TECHNOLOGICAL GAPS IN DESIGN AND STRUCTURE OF POLYHOUSES

(per cent)

Sr. No.	Particulars	Technological gap		
		Small Farms	Large Farms	Overall Farms
(1)	(2)	(3)	(4)	(5)
1.	Proper site selection	48.48	62.96	55.00
2.	Orientation of polyhouse	39.39	40.74	40.00
3.	Properly secured foundation	66.67	70.37	68.33
4.	Thickness of polyfilm size (120 GSM)	42.42	40.74	41.67
5.	Strength of frames	24.24	25.93	25.00
6.	Double door entry	9.09	18.52	13.33
7.	Doors are at an appropriate angle	69.70	70.37	70.00
8.	Foot dip	30.30	25.93	28.33
9.	Use of thermometer	81.82	81.48	81.67

Technological Gaps in Input Use

Technological gaps in input use were worked out by comparing the actual input use by average farmers in the study area and have been given in Table 7. It was observed that the farmers usually used more seed and seedlings than the frontier practice in all the three crops and both the categories, thus, maintaining higher plant density and narrower spacing. Hence, negative gaps (showing excess use) were observed for seed and seedlings in small polyhouses while it was positive for large polyhouses. Similarly, in case of composts and fertilisers, especially nitrogenous fertilisers, the excessive use was observed on average farms. The use of nitrogenous fertilisers was more than frontier practice but the use of NPK (19:19:19) through fertigation was comparatively less and this gap varied from about 12 to 64 per cent on small farms however, on large farms it was 53 to 76 per cent. The expenses made for plant protection by small farmers were more than the frontier farmers in case of tomato and cucumber whereas on large farms positive gaps were reported in capsicum and cucumber. The gap in output was found to vary from 26 per cent for cucumber to 36 per cent for tomato on small farms and from 53 per cent for tomato to 56 per cent for capsicum, on large farms.

It can further be observed from the table that the magnitude of gaps (whether +ve or -ve) for majority of the inputs in all the three crops and both the categories of farms did not measure as high as it was observed for various management practices and design/structure of polyhouse. This concludes that in order to reduce the yield gaps, more attention is required to be paid towards the improvement in management practices followed inside the polyhouses as well as the design or structure of the polyhouses. Sharma *et al.* (2015) also reported noticeable technological gaps in experimental and farmers' polyhouse units with respect to input use and management practices.

TABLE 7.TECHNOLOGICAL GAPS (PER CENT) IN INPUT USE

(per 100 m^2)

Inputs	Capsicum			Tomato			Cucumber		
	Frontier Practice	Gap		Frontier Practice	Gap		Frontier Practice	Gap	
		Small farms	Large farms		Small farms	Large farms		Small farms	Large farms
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Seed (g)	4.50	-5.78	19.3	4.50	-5.56	25.1	-	-	
Seedlings (number)	450.0	-4.44	17.8	460.0	-3.26	20.6	418.0	-2.53	9.81
Compost (FYM) (q)	1.00	-43.0	-19.0	1.50	2.00	22.0	1.00	-43.00	-19.0
Vermicompost (kg)	2.00	11.5	4.00	2.00	-1.50	22.0	1.80	-6.11	12.22
Fertilisers (kg)									
Urea	0.38	-5.26	-2.63	0.50	-4.00	22.0	0.50	2.00	22.00
SSP	1.80	8.89	11.7	2.00	4.00	61.0	1.50	-27.33	29.33
MOP	0.20	-70.0	-30.0	0.60	36.7	53.3	0.40	27.50	40.00
NPK (19:19:19)	2.40	31.7	52.9	2.30	11.7	53.9	4.00	64.25	76.00
Plant protection materials (Rs.)	1072	47.9	52.2	550.0	-7.73	-7.68	570.0	-4.81	7.95
Spacing (cm^2)	1800	32.6	10.0	1800	5.56	4.44	1800	7.61	5.56
Human labour (man-days)	36.00	3.69	20.8	38.30	-0.86	18.0	26.50	-22.49	0.42
Output (q)	13.00	31.2	55.7	14.01	36.5	53.5	15.50	25.74	40.58

Note: (-) sign shows the excess use.

IV

CONCLUSIONS AND POLICY IMPLICATIONS

A wide gap was observed in the yields of frontier and average farmers. Significantly high gaps were observed in the management practices like seed and soil treatments, pinching/pruning, spacing and plant protection. Existing design and structure of sampled polyhouses was also found to be faulty. Negative gaps were observed in case of the inputs viz., seed, seedlings, composts, nitrogenous fertilizers, MOP and plant protection chemicals in different crops indicating excessive use by average farmers. Faulty management practices, faulty construction/design of polyhouse and scant attention of farmers towards precautionary measures were mainly responsible for yield gaps in different crops. This was also because the selection of genuine farmers and their training before installation of the polyhouses was not ensured.

Therefore, concerted efforts are required from all concerned research, developmental and extension agencies to develop economically viable and technologically feasible polyhouse technology suitable for different agro-climatic and geographical conditions. Suitable technologies need to be disseminated with utmost precision and full sincerity so that they work successfully and the farming community gets encouraged to adopt more and more of these. Some of the suggestions needed to improve the efficiency of protected cultivation technology in future are.

1. A method should be devised for the selection of genuine farmers. Prior training should be made a pre requisite for sanctioning the case for subsidy.

2. The beneficiary farmers should be provided with the detailed information about the standard design and structure of polyhouses preferably by arranging a visit to model polyhouse farm so as to reduce the chances of faulty construction and cheating by construction firms. The construction companies should be made accountable for any deviation and damage within a fixed time period.

3. There is an utmost need to standardize crops and cropping systems so that the polyhouse is utilised to its optimum capacity throughout the year.

4. Provision of huge subsidy on protected cultivation may have affected the selection of genuine farmers and hence the success of the venture. So, it should be given a thought in future schemes.

5. Efficient advisory services should be made available to the farmers at their door steps to tackle various pests and other problems related to protected cultivation. The officials of State Department of Agriculture should also be imparted advanced trainings on protected cultivation so that they are able to provide proper advice to polyhouse beneficiaries.

6. There is a dire need to bring polyhouses under insurance cover to make the scheme more sustainable in future.

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