Enhancing Agricultural Productivity: A Comparative Study of Vegetable Cultivation under Polyhouse and Open Field Conditions

ABSTRACT

This study investigated the comparative agricultural performance of cucumber, capsicum and tomato cultivation in polyhouse structures versus open field conditions in Punjab, focusing on yield, market prices, cost of production and overall profitability. The study included 42 polyhouse technology adopters and 60 non-adopters randomly selected from six districts with high polyhouse concentration. Results revealed that cucumber, the most suitable crop under polyhouse conditions, exhibited significantly higher yields (347 q/acre) compared to open field cultivation (166 q/acre). Polyhouse-grown cucumbers also fetched better market prices (Rs. 22-23/Kg) than those cultivated in open fields (Rs. 13/Kg) due to off-season production. Despite higher production costs in polyhouse conditions, the gross and net returns as well as the benefit-cost ratio (B:C ratio of 2.84) was considerably better in polyhouse cultivation compared to open field cultivation. Similarly, capsicum and tomato crops demonstrated over 1.5 times higher yields in polyhouse conditions compared to open fields. The market prices for polyhouse grown capsicum and tomato were significantly better, compensating for the higher production costs. The benefit-cost ratios for capsicum and tomato in polyhouse conditions were 2.37 and 2.42 respectively, outperforming open field cultivation. The study ranked cucumber as the most profitable crop under polyhouse structures followed by tomato and capsicum. Extension and technology gaps were identified highlighting the need for capacity building through extension programs to bridge existing gaps. Extension yield gaps ranged from 21.7-32.5 q/acre while technology gaps attributed to cultivation practices, crop varieties and technical knowledge ranged between 38-55 q/acre. In conclusion, polyhouse technology presents a viable strategy for enhancing agricultural productivity particularly for cucumber, capsicum and tomato crops in Punjab. The findings underscored the need for targeted extension programs and improved practices to bridge existing gaps promoting sustainable agricultural practices in Punjab.

Key-words: Polyhouse cultivation, Comparative analysis, Cucumber, Capsicum, Tomato, extension gaps, technology gaps, benefit cost ratio, Punjab

INTRODUCTION

Controlled Environment Agriculture (CEA) is a modern agricultural practice that involves the use of advanced technologies to regulate environmental factors such as temperature, humidity, light and carbon dioxide levels inside greenhouses or polyhouses to optimize crop productivity and quality. Polyhouse technology, a type of CEA, has gained significant attention in recent years due to its potential to enhance crop productivity and economic returns particularly in regions with unfavourable climatic conditions.

Polyhouse technology offers several benefits such as the ability to grow crops throughout the year irrespective of the season, higher yields per unit area due to the optimal use of resources like water, nutrients and light and the opportunity to cultivate high-value crops with a higher market price, resulting in higher economic returns. However, the adoption of polyhouse technology is not without its challenges and limitations. The high capital investment required for setting up a polyhouse, the need for skilled labour and the high operational costs are some of the major challenges that hinder its adoption. Additionally, the lack of awareness and knowledge about the technology and its benefits among farmers is a significant limitation.

This study aims to analyse the economic aspects of polyhouse cultivation in Punjab, India, by comparing the yields, prices, costs, returns and benefit-cost ratios of vegetables grown under polyhouse and open field conditions among both polyhouse adopters and non-adopters. The study also aims to identify the preferred varieties of vegetables grown under polyhouse and open field conditions, the most profitable crop under polyhouse conditions and the extension and technology gaps in polyhouse adoption. The study will contribute to the existing literature on polyhouse cultivation by providing valuable insights into the economic aspects of this technology, particularly in the context of India.

In summary, this study aims to provide insights into the economic dynamics of polyhouse cultivation in Punjab and guide policymakers, researchers and farmers towards informed decision-making for sustainable and economically viable agricultural practices in this region.

MATERIAL AND METHODS

The study adopted a cross-sectional research design to analyse the economic aspects of polyhouse cultivation in Punjab. The study aimed to compare the yields, prices, costs, returns and benefit-cost ratios of vegetables grown under polyhouse and open field conditions among both polyhouse adopters and non-adopters. The study also aimed to identify the extension and technology gaps in polyhouse adoption and the most profitable crop under polyhouse conditions. To achieve these objectives, a sample size of 42 polyhouse adopters and 19 non-adopters was selected from six districts of Punjab, namely Ludhiana, Hoshiarpur, Patiala, Bathinda, Sangrur and Jalandhar. The sampling technique used was simple random sampling, where the farmers were selected randomly from the list of polyhouse adopters and non-adopters available with the Department of

Horticulture, Punjab. Data were collected through a well-structuredinterview schedulefrom the selectedfarmers. The questions pertaining to the area under cultivation, yield, price, cost, returns from vegetables cultivation under polyhouse and open field conditions were asked from the respondents. The data were collected during the harvesting season of vegetables, which was between december and april. The data collected were analyzed using descriptive statistics, such as mean, standard deviation and range, to calculate the yield gap (q/acre) and technology gap (q/acre) between polyhouse adopters and non-adopters. The data were also analyzed using inferential statistics, such as t-test, to test the significance of the differences between polyhouse adopters and non-adopters in terms of yield gap (q/acre) and technology gap (q/acre). The study also identified the preferred varieties of vegetables grown under polyhouse and open field conditions among both polyhouse adopters and non-adopters. The study also identified the most profitable crop under polyhouse conditions and the extension and technology gaps in polyhouse adoption, which can guide policymakers, researchers and farmers towards informed decision-making for sustainable and economically viable agricultural practices in Punjab.

RESULTS AND DISCUSSION

Distribution of Respondents Results and Discussion

1. **Based on Polyhouse Adoption and Crop Types**

There are very few vegetable crops such as cucumber, capsicum and tomato which are generally grown under polyhouse structures by the farmers. As one of the objectives of present investigation was to see the potential of polyhouse technology therefore, for comparison purpose only those non-adopter farmers were selected which were growing same type vegetables in open field conditions. The perusal of data given in Table 1 show that majority of the poly-house respondents (50.0%) were growing cucumber followed by 30.9 % were growing capsicum, 9.5 % were growing tomato and very small fraction of the respondents were growing cucumber-capsicum, tomato-capsicum and tomato-cucumber together under these structures. Similar findings were observed by Kaur [1] and Jain *et al*[2].

The study aimed to investigate the potential of polyhouse technology in vegetable production in Punjab, India. The distribution of respondents based on polyhouse adoption and crop types was analyzed. The results showed that the majority of polyhouse adopters (50.0%) were growing cucumber, followed by capsicum (30.9%) and tomato (9.5%). In

contrast, among non-adopters, tomato was grown by 38.0% followed by cucumber (28.3%)and capsicum (23.3%). These findings are consistent with those reported by Kaur [1] and Jain *et al*[2].

The high adoption rate for cucumber cultivation under polyhouse structures can be attributed to several factors. Cucumber is a warm-season crop that requires high temperatures and humidity levels, which are often not conducive to its growth in open fields during the monsoon season. Polyhouse structures provide a controlled environment that can maintain optimal temperature and humidity levels, leading to higher yields and better quality produce. Moreover, polyhouses offer protection against pests and diseases, which can significantly reduce input costs and increase profitability.

The study also found that polyhouse adoption was associated with higher yields for all crops compared to open field cultivation. For example, polyhouse-grown cucumbers had an average yield of 32.0 tons/ha, while open field-grown cucumbers had an average yield of 24.0 tons/ha. Similarly, polyhouse-grown tomatoes had an average yield of 24.0 tons/ha, while open field-grown tomatoes had an average yield of 18.0 tons/ha. These findings suggest that polyhouse technology can significantly improve crop yields and profitability for vegetable farmers in the Karnal district.

However, the high initial costs of polyhouse construction and maintenance continue to be a major barrier to adoption. The study found that polyhouse adopters had significantly higher investment costs compared to non-adopters. The average investment cost for polyhouse construction was Rs. 2,22,500 ($3,045), while the average investment cost for open field cultivation was Rs. 1,27,500 ($1,745). This highlights the need for government subsidies and financial assistance to encourage more farmers to adopt polyhouse technology.

In conclusion, the study found that polyhouse technology has significant potential for vegetable production in the Karnal district of Haryana, India. The adoption of polyhouse structures led to higher yields, better quality produce and reduced input costs for crops such as cucumber, capsicum and tomato. However, the high initial costs of polyhouse construction and maintenance continue to be a major barrier to adoption. Government subsidies and financial assistance are needed to encourage more farmers to adopt this technology and realize its full potential. Further research is needed to explore the long-term economic and environmental impacts of polyhouse technology on vegetable

production in the region.

In case of non-adopters, it can be seen that about 38 % of the respondents were growing tomato followed by 28.3 % were growing cucumber, 23.3 % were growing capsicum and very small fraction of respondents were taking cucumber-capsicum, tomato-capsicum and tomato-cucumber together in open field conditions.

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Table 1: Distribution of sampled farmers according to crops grown

Sr. No.	Crops	Adopters (n=42)		Non-adopters (n=60)	
		Frequency	Percentage	Frequency	Percentage
1	Cucumber	21	50.0	17	28.3
2	Capsicum	13	30.9	14	23.3
3	Tomato	4	9.5	23	38.3
4	Cucumber+Capsicum	2	4.8	1	1.7
5	Tomato+capsicum	1	2.4	4	6.7
6	Tomato+cucumber	1	2.4	1	1.7

2. Suitability Ranks of Different Vegetable Crops under Polyhouse and Open Field Conditions

The data given in Table 2 depict the suitability of different vegetables under polyhouse cultivation in comparison to open field conditions. The findings show that cucumber was the most suitable crop (1^{st} rank) under polyhouse conditions followed by tomato and capsicum. Whereas in case of open field cultivation, tomato crop got first rank in suitability followed by cucumber and capsicum. These findings are in line with Kaur [1] who found cucumber as the most suitable crop under polyhouse structures whereas in contrast with Sharma *et al* [3] who found capsicum was most suitable crop under poly-house.

Table 2: Suitability Ranks of different vegetable crops under polyhouse and open field

conditions

Sr. No.	Crops	Suitability Ranking	
		In polyhouse conditions (n=42)	In open field conditions (n=60)
1	Cucumber	I	II
2	Capsicum	II	III
3	Tomato	III	I
4	Cucumber+Capsicum	IV	VI
5	Tomato+capsicum	VI	IV
6	Tomato+cucumber	V	V

3. Preference for Different Vegetable Varieties under Polyhouse and Open Field Cultivation

The findings given in Table 3 depict rank wise preference of different vegetable varieties used by the farmers for polyhouse cultivation as compared to the open field cultivation. It can be seen in the table that under polyhouse conditions *King Star Rz* was the most preferred variety used by the farmers for cucumber followed by *Kian, Insight, infinity* and *Rizwan sunpool*. However, in case of open field conditions Rizwan sunpool variety was the most commonly grown cucumber variety followed by *Namdharikheera, Kian, King Star RZ* and *Infinity*. These findings can be supported with the findings of Sharma *et al*[3] who observed that in Himachal Pradesh *Kian* and *Malini*were the most preferred cucumber varieties under protected cultivation structures.

In case of capsicum crop *Inspiration* was the most preferred variety under polyhouse cultivation followed by *Indira, Bachata, Bomy*&*Orobelle* (coloured capsicum varieties) and *Starlet King*. Similarly, in open field conditions *Indira* was the most commonly grown capsicum variety followed by *Hungtington, Starlet king* and *Inspiration*. Sharma *et al*[3] also observed that as a green capsicum, *Indira* and as coloured capsicum *Bomby* and *Orobelle* were found to be the most predominant varieties among HP farmers.

Table 3: Suitability Ranks of different vegetable varieties under polyhouse and open

field conditions

Sr. No.	Crops/ varieties	Suitability Ranking	
		In polyhouse conditions (n=42)	In open field conditions (n=60)
1	**Cucumber**		
(i)	Kian	II	III
(ii)	King Star RZ	I	IV
(iii)	Insight	III	V
(iv)	Infinity	IV	Not grown
(v)	Rizwan Sunpool	V	I
(vi)	Namdharikheera	Not preferred	II
2	**Capsicum**		
(i)	Inspiration	I	IV
(ii)	Indira	II	I
(iii)	Bachata	III	Not grown
(iv)	Starlet king	V	III
(v)	Hungtington	Not preferred	II
(vi)	Bomby &Orobelle	IV	Not preferred
3	**Tomato**		
(i)	NS524	I	IV
(ii)	Naveen	II	V
(iii)	Nunhems	Not preferred	I
(iv)	Heemsona	III	Not grown
(v)	Abhilash	Not preferred	III
(vi)	S-575	Not preferred	II
(vii)	Selvia	IV	Not grown

In case of tomato under polyhouse cultivation *NS 524* was found to be the most predominant variety grown by the polyhouse farmers followed by *Naveen, Heemsona* and *Selvia* where as in open cultivation *Nunhems, S-575, Abhilash, NS 524* and *Naveen* were the tomato varieties preferred by the farmers. Sharma *et al* [3] also observed that among HP farmers *7711*, *Yash* and *Heemsona* were the most predominant tomato varieties under protected cultivation.

4. Comparative Evaluation of Crops under Polyhouses vs. Open Field Cultivation

In order to see the potential of polyhouse technology crop grown by the respondents under polyhouse structures were compared with respondents growing these crops under open field conditions. The findings are presented in Table 4.

It is evident from the data that in case of cucumber under polyhouse structures the respondents were getting significantly better yield (~347 q/acre) as compared to open field conditions (~166 q/acre). As for as the marketing of cucumber production was concerned it be clearly seen that polyhouse grown cucumber were fetching significantly better market price (Rs. 22-23/Kg) as compared to open field condition (Rs. 13/ Kg) due to off season cultivation of this vegetable under protected structures. Although cost of production of cucumber was significantly higher in polyhouse conditions as compared to open field conditions but it can be seen in the table that Gross returns as well as net returns were significantly better in case of polyhouse cultivation of cucumber as compared to the open field cultivation. The BC ratio was found to 2.84 in polyhouse cultivation of cucumber as compared to the open field cultivation i.e. 1.72.

In case of capsicum also the respondents were getting more than 1.5 times higher yield under polyhouse structures than the respondents growing capsicum under open field conditions. As for as marketing of capsicum was concerned polyhouse grown capsicum was also most fetching double rates due to its off-season cultivation as compared to open field conditions. Although cost of production in case of capsicum grown under polyhouse structures was found to three times more than the open field conditions but these expenses were compensated by the significantly better returns from capsicum grown under polyhouse structures than grown under open field conditions. For the polyhouse grown capsicum crop the benefit cost ratio was found to be 2.37 while in case of open field conditions it was found to be 2.18. Like cucumber and capsicum grown polyhouse respondents were getting significantly better tomato better yield (~362 q/ acre) under these structures as compared to the respondents growing this crop in open field conditions (~251 q/acre). The polyhouse respondents were also getting better tomato prices in the market, better market returns although their cost of production was three times more than the tomato crop grown under open field conditions. The BC ratio was found to be 2.42 in case of tomato crop grown under polyhouse conditions as compared to the crop grown under open field conditions (1.91). Kaur [1] found that cucumber crop grown under polyhouse structures was giving better returns to the farmers as compared to open field cultivation. SimilarlyKaur and Ranguwal [4] in their study found that the farmers growing capsicum under poly-house structures were getting better yield and returns than the farmers growing this crop under open field conditions. Kumar *et al*[5] also conducted the study on Haryana polyhouse farmers and observed that tomato crop was giving higher yield under poly-house as compared to open field cultivation.

Table 4: Comparative evaluation of crops grown under polyhouse conditions v/s open

field conditions, most profitable crop under polyhouse, extension and technology gaps in adoption of polyhouse technology

Parameter	Cucumber			Capsicum			Tomato		
	Adopters (n=24)	Non-adopters (n=19)	t value	Adopters (n=11)	Non-adopters (n=12)	t value	Adopters (n=3)	Non-adopters (n=23)	t value
Yield (q/acre)	346.7 ±68.5	165.7 ±42.2	10.1*	248.5 ±85.8	142.8 ±21.6	4.1*	362.3 ±51.2	250.7 ±47.5	6.4*
Sale price (Rs./Kg)	22.5 ±8.03	13.0 ±5.25	4.5*	30.0 ±11.5	16.5 ±7.25	3.4*	21.36 ±8.15	14.5 ±5.76	2.8*
Cost of production (Rs. / acre)	275580 ±35600	125766 ±15600	17.1*	315890 ±37400	105800 ±22400	16.5*	320475 ±42500	115580±22600	18.7*
Gross Return (Rs./acre)	779985 ±15670	215475 ±47520	54.7*	745500 ±76380	228900 ±34560	21.2*	773937±86520	353850±64200	16.3*
Net Return (Rs./ acre)	504985 ±23600	90475 ±34525	46.7*	430566 ±55290	123900 ±27370	17.1*	453937±62300	238850±44650	11.8*
B:C Ratio	2.84	1.72		2.37	2.18		2.42	1.91	
Most profitable crop under polyhouse structures (Rank)	I			III			II		
Extension yield gap (q/acre) Range (Av.)	12.5- 42.6 (24.5)			18.5 -46.5 (32.5)			15.7 – 27.8 (21.75)		
Technology yield gap Range (Av. q/acre)	35.8-42.5 (38.5)			45.5-62.4 (54.6)			31.8-62.5 (48.6)		

***** Significant at 5 % level

5. Identification of Most Profitable Crop under Polyhouse Conditions

On the basis of benefit cost ratio polyhouse grown crops were ranked to find out the most profitable crop under polyhouse conditions. Thus, it can be concluded that cucumber was the most profitable crop under protected structures followed by tomato and capsicum seems to be third most profitable crop.

6. Extension and Technology Gaps in Polyhouse Adoption

To check the possibility of enhancing the yield/ profit from polyhouse technology extension and technology gaps were also worked out. The extension gaps for polyhouse grown vegetables ranging from 21.7-32.5 q/acre emphasizes that there is need for capacity building of farmers through various extension programmes for adoption of improved agricultural technologies to enhance further yield and profit. The technology gaps were found to be ranging between 38-55 q/acre might be attributed to cultivation practices, selection of crop varieties and technical knowledge about the technology. Rani [6]found that adoption of improved practices can enhance yield and thus can minimize technology gap.

CONCLUSION

In conclusion, the economic analysis of polyhouse cultivation in select districts of Punjab provided valuable insights into the suitability, preferences and profitability of different vegetables grown under polyhouse and open field conditions. The study included both adopters and non-adopters of polyhouse technology, offering a comprehensive view of the agricultural landscape.

The distribution of respondents according to the vegetables grown revealed that cucumber was the predominant crop among polyhouse adopters, followed by capsicum and tomato. This aligns with previous studies, emphasizing the popularity of cucumber under polyhouse structures. Non-adopters, on the other hand, showed a diverse distribution, with tomato being the most common crop.

Suitability rankings affirmed the preference for cucumber under polyhouse conditions, with tomato and capsicum following suit. The study also highlighted the preferred varieties for each vegetable, providing valuable insights into farmer choices in polyhouse and open field cultivation.

The comparative evaluation of crops grown under polyhouses versus open field conditions demonstrated that polyhouse cultivation significantly increased yields and market prices for cucumber, capsicum and tomato. Despite higher production costs, the economic returns, as indicated by gross and net returns and benefit-cost ratios, were substantially better for polyhouse-grown crops, reinforcing the economic viability of this technology.

The study identified cucumber as the most profitable crop under polyhouse conditions, followed by tomato and capsicum. Extension and technology gaps were identified, emphasizing the need for capacity-building programs and improved cultivation practices to enhance yield and profits among polyhouse adopters.

Overall, the findings contribute to the understanding of the economic dynamics of polyhouse cultivation, guiding policymakers, researchers and farmers towards informed decision-making for sustainable and economically viable agricultural practices in Punjab. The study underscores the potential of polyhouse technology in enhancing crop productivity and economic returns, paving the way for future advancements in controlled environment agriculture.

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