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Original Research Article

Prospects and Constraints of Vegetable Production under Protected and Open-field Cultivation: A Comprehensive Assessment of Haryana

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Abstract: Protected cultivation has emerged as a major technological intervention in Indian horticulture, providing opportunities to enhance productivity, improve quality, to provide supply of all the vegetables through out of year and stabilizes farm incomes. Hence, the new agriculture technology of protected cultivation (net house, poly house, walk in tunnel etc.) is on the rise in all parts of India and in Haryana. However, the farmers who have adopted these new techniques faced many production and marketing challenges i.e. lack of government subsidies, timely marketing facilities and lack of quality assurance of their produce. Hence, the present study is making an attempt to highlight these Production and Marketing Challenges in Vegetable Crops. This study compares the prospects and constraints of vegetable cultivation in protected and open field condition in the state of Haryana. The study has relied on primary data obtained from 300 farmers (150 farmers under protected cultivation and 150 farmers under open field cultivation). The findings show that protected cultivation can provide substantial agronomic and economic advantages, such as increased productivity, quality, out-of-season production and year-round employment. On the other hand, farmers have to deal with challenges like high investment, lack of skilled manpower, reliance on technical advice and vulnerability to structural damage during climatic events. On the other hand, open field farmers face problems such as heavy weed infestation, pest and disease occurrence, poor quality of inputs and increased transportation expenses. The marketing dimension emerges as a major bottleneck for both systems due to unstable prices, lack of minimum support price (MSP), inadequate cold-storage facilities and unorganized market structures. The study suggests policy interventions focusing on infrastructure development, extension services and to upgrades marketing facilities to improve the viability of vegetable cultivation across both systems.

Keywords: Protected Cultivation, Open-field farming, Vegetable Marketing, Production Constraints, Weighted Mean Score.

1. INTRODUCTION

In India, vegetable cultivation plays a vital role in ensuring food security and is a part of the livelihoods of farmers, generating their income and employment. India is the second largest vegetable producer in the world, but there are various challenges to increasing vegetable productivity, such as climatic variability, small and scattered holdings, infrastructure constraints, and fluctuating prices (FAO, 2021). To overcome these problems, protected cultivation technologies like poly houses, net houses and walk-in tunnels have come up as a viable alternative to improve productivity and stabilize the output. Protected cultivation is considered as a micro-environment which can help the growers in

controlling the negative impacts of weather conditions, using the resources optimally and extending the cropping season (Kumar *et al*., 2015).

Protected cultivation has been shown to achieve significant improvements in yield and water use efficiency globally. Research in Spain, Israel and the Netherlands indicates that greenhouse vegetable production can be 2 to 5 times more productive than open field systems, primarily because of better environmental control and precision input management (Dorais, 2019; Pascale *et al*., 2017). In Asia, China has been widely using low-cost plastic greenhouses, and therefore, the number of off-season vegetable markets has increased rapidly (Li *et al*., 2020). The results show that protected cultivation has the potential to be a game-changer in regions exposed to climate risks and land limitations.

Protected cultivation is on the rise in India under schemes like the Mission for Integrated Development of Horticulture (MIDH) and state horticulture missions. Haryana has emerged as a leading state in adopting protected structures due to government subsidies and market-oriented vegetable production. Research in Haryana and neighbouring states has shown that protected cultivation can generate higher returns per unit area, better quality attributes and provide year-round employment to farm households (Mehta *et al*., 2020; Kumari & Singh, 2019). Protected cultivation has its limitations, however, such as the high capital costs, lack of technical expertise, shortage of skilled labour and susceptibility to wind and hail.

Open field vegetable production system, which is prevalent in India, faces constant threats like pest and disease incidences, weed infestation, substandard planting material and climate uncertainties. Smallholders face additional challenges such as price volatility, excessive transportation expenses, poor storage conditions, and poorly organized mandis, which further diminish profitability (Chand *et al*., 2018; NITI Aayog, 2021).

In the face of the increasing research on horticulture, there is a lack of comparative evidence of farmers' perspectives on prospects and constraints of protected and open field vegetable production in one analytical framework. This study fills that gap by presenting a comprehensive assessment based on primary data from Haryana.

The study builds on the available literature by comparing the agronomic and economic potential of protected and open field cultivation systems, identifying the production constraints faced by both cultivation systems, assessing the marketing constraints that limit farmers' profitability, and providing policy recommendations based on empirical evidence derived from field data. The results are applicable to horticultural planning, subsidy design, extension services, and market reforms for enhancing the sustainability of vegetable farming in India.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in three major vegetable districts of Haryana: Hisar, Jind and Sonipat having different agro-ecological and market conditions. These districts have experienced significant implementation of protected cultivation systems like poly houses and net houses, and are also recognized for the extensive production of open field vegetables, especially cucumber, tomato, capsicum, and leafy vegetables. Semi-arid climatic conditions, frequent temperature changes and occasional hailstorms make the region appropriate for comparative evaluation of protected and open field agriculture.

2.2 Sampling Design

A multi-stage stratified random sampling technique was employed. The three districts were purposively selected because of their status in vegetable production during the first stage. The second stage involved identifying villages that had significant amounts of protected and open-field cultivation, using the support of the State Horticulture Department. In the third stage, farmers were randomly selected. The sample consisted of 300 farmers, which included 150 farmers under protected cultivation and 150 farmers under open field vegetable cultivation. A total of 50 protected cultivation farmers and 50 open-field vegetable farmers were selected from each of the three selected districts, keeping balanced number of farmers from both cultivation systems and districts.

2.3 Data Collection

The primary data was gathered using a structured and pre-tested questionnaire that was administered by face-to-face interviews. The questionnaire focused on three broad areas: (1) prospects of vegetable production under each system (2) production constraints to output and operations, and (3) marketing constraints to post-harvest management and profitability. The instrument also captured information on farmer characteristics, cropping patterns, input use, yield levels, access to markets, price realization and extension support. To supplement the primary data, secondary data was also collected from different sources such as Mission for Integrated Development of Horticulture (MIDH), National Horticulture Board (NHB), Food and Agriculture Organization of the United Nations (FAO) and the Haryana Horticulture Department.

2.4 Analytical Framework

2.4.1 Weighted Mean Score (WMS) Method

A dichotomous scale (Yes=2, No=1) was used to record the farmers' response to each constraint or prospect.

The following formulas were used:

Weighted Score (WS): WS=(2×Yes) + (1×No)

Weighted Mean Score (WMS): WMS=WS/N

where N = 150 (number of respondents per system).

Ranking Method

The study has added to the existing literature by comparing the agronomic and economic potential of the protected and open field cultivation systems, highlighting the production constraints faced by both cultivation systems, assessing the marketing constraints that affect the farmers' profitability and proposing policy recommendations based on empirical evidence developed from the field data.

3. RESULTS AND ANALYSIS

This section combines the findings of protected and open field vegetable farmers using Weighted Mean Scores (WMS) and ranked perceptions. The results are summarized in three analytical sections: (1) Prospects of cultivation systems (2) Production constraints, and (3) Marketing constraints. Comparative summaries are provided to emphasise cross-system differences.

3.1 Prospects of Protected and Open-field Cultivation

Table 1: Comparative Prospects of Protected and Open-field Vegetable Cultivation

Prospect	Protected (WMS)	Rank	Open-field (WMS)	Rank	Interpretation
Higher productivity per unit area	1.99	1	1.45	4	Protected cultivation provides superior yield advantages.
High-quality produce	1.98	2	1.62	3	Quality enhancement is strongly associated with protected systems.
Suitability for off-season production	1.91	5	1.00	7	Off-season cultivation is largely absent in open-field conditions.
Efficient fertilizer use	1.90	6	1.75	2	Both systems benefit, but protected is marginally higher.
Vertical cultivation possibilities	1.92	4	1.00	7	Exclusive advantage under polyhouse/net-house systems.
Multiple cropping	1.97	3	2.00	1	Both systems allow multiple cropping; open-field slightly more flexible.
Year-round employment	1.97	3	1.15	6	Protected farming generates more employment due to continuous care.
Reduced climatic risks	1.85	8	1.30	5	Controlled environments substantially reduce weather-related losses.
Export suitability	1.87	7	1.00	7	Superior quality under protected systems supports export potential.

Source: Primary Survey

A comparative assessment of the prospects of the protected and open field vegetable farming was carried out from the Weighted Mean Scores (WMS) obtained from the sampled farmers as presented in Table 1. The results reveal that protected cultivation offers greater agronomic and economic advantages than open-field cultivation for most of the selected parameters.

The identified prospects with higher values were: high productivity per unit area (WMS = 1.99), high quality produce (1.98), multiple cropping and year-round employment generation (1.97 each), vertical cultivation possibilities (1.92), off-season production (1.91), efficient fertilizer use (1.90), export suitability (1.87) and reduced climatic risks (1.85). The results suggest that protected cultivation offers a controlled production area that boosts productivity, quality of production, continuous production and job creation.

In contrast, multiple cropping had the highest WMS (2.00) followed by efficient fertilizer use (1.75), high quality produce (1.62), higher productivity per unit area (1.45), reduced climatic risks (1.30), year-round employment generation (1.15), off-season production (1.00), vertical cultivation possibilities (1.00) and export suitability (1.00). The results indicate that, while open field cultivation allows for various crops in a single area, the overall potential is limited due to climatic variability and the lack of high value vegetable production.

In general, the results showed that protected cultivation has a better production and market potential than open field cultivation as far as productivity, quality enhancement, out-of-season production and employment generation are concerned. The findings are in line with the results of Dorais (2019) and Li *et al*. (2020) which demonstrated that protected cultivation significantly improves productivity, product quality and competitiveness.

3.2 Constraints of Protected and Open-field Cultivation

3.2.1 Comparative Production Constraints

Table 2. Production Constraints under Protected and Open-field Cultivation

Constraint Category	Protected Cultivation (WMS)	Severity	Open-field Cultivation (WMS)	Severity	Interpretation
High investment cost	1.88	High	1.59	Moderate	Protected requires capital-intensive infrastructure.
Lack of skilled labour	1.97	Very High	1.63	High	Technical complexity greater under protected structures.
Quality seed availability	1.56	Medium	1.75	High	Open-field farmers experience poorer seed quality.
Pest and disease incidence	1.76	High	1.81	Very High	Open-field more vulnerable to pests and diseases.
Weed infestation	1.71	Medium	1.83	Very High	Major challenge only in open-field farming.
Climate-related damage	1.93	Very High	1.72	High	Protected structures susceptible to storm-related damage.
Technical guidance gaps	1.89	Very High	1.42	Medium	Protected farmers require more extension support.

Source: Primary Survey

A comparative analysis of production constraints faced by farmers under protected and open-field cultivation is presented in Table 2, based on Weighted Mean Scores (WMS). The results show that the nature of production constraints varies significantly between the two cultivation systems.

The most critical constraint identified under protected cultivation was lack of skilled labour (WMS = 1.97), followed by climate-related damage (1.93), technical guidance gaps (1.89), high investment cost (1.88), pest and disease incidence (1.76), weed infestation (1.71), and quality seed availability (1.56). The findings indicated that protected cultivation is limited primarily due to the high cost of investment, complexity of techniques and the requirement for constant professional guidance.

Weed infestation was the highest WMS (1.83) in open field cultivation, followed by pest and disease incidence (1.81), quality seed availability (1.75), climate related damage (1.72), lack of skilled labour (1.63), high investment cost (1.59) and gaps in technical guidance (1.42). The results show that biological and environmental factors affecting productivity and production risk are the main factors affecting open-field cultivation.

Overall, the results reveal that protected cultivation is mainly limited by economic and technical constraints, whereas open-field cultivation is more vulnerable to biological and climatic challenges. Thus, the two cultivation systems need different policy and extension support strategies to increase their productivity and sustainability.

3.2.2 Comparative Marketing Constraints

Table 3: Marketing Constraints under Protected and Open-field Cultivation

Marketing Issue	Protected Cultivation (WMS)	Rank	Open-field Cultivation (WMS)	Rank	Interpretation
Unstable prices	1.99	2	1.95	2	Major issue across systems.
Lack of MSP	2.00	1	2.00	1	No MSP exists for vegetables; universal constraint.
Unorganized markets	1.97	3	1.93	3	Structural inefficiencies affect price realization.

Marketing Issue	Protected Cultivation (WMS)	Rank	Open-field Cultivation (WMS)	Rank	Interpretation
High transportation cost	1.72	6	1.84	4	Open-field farmers more affected due to greater distance and perishability.
Lack of cold storage	1.95	4	1.12	8	Protected farmers produce higher-value crops needing cold chain.
Packaging material scarcity	1.52	7	1.61	6	Moderate constraint for both.
Market information gaps	1.77	5	1.69	5	Information asymmetry prevalent in both systems.
Heavy market losses	1.45	8	1.18	7	Both face post-harvest losses, but open-field more severe.

Source: Primary Survey

Table 3 shows a comparative analysis of farmers' marketing constraints under protected and open-field farming systems using Weighted Mean Scores (WMS). The results indicate that marketing constraints exist throughout both cultivation systems, but are not necessarily severe.

The highest WMS was recorded for lack of Minimum Support Price (MSP) (2.00), unstable prices (1.99), unorganized markets (1.97), lack of cold storage facilities (1.95), market information gaps (1.77), high transportation cost (1.72), packaging material scarcity (1.52), and heavy market losses (1.45). The results suggest that the protected cultivation farmers have more difficulties with the marketing of high value and perishable products because of the lack of post-harvest infrastructure.

In the same way, lack of MSP (2.00) and unstable prices (1.95) were the most serious marketing constraints under open field cultivation, followed by unorganized markets (1.93), high transportation cost (1.84), market information gaps (1.69), packaging material scarcity (1.61), lack of cold storage facilities (1.12) and heavy market losses (1.18). The findings indicate that open field farmers face more of the transportation-related issues and the poor marketing infrastructure.

Overall, the findings demonstrate that marketing constraints are systemic in nature and affect both cultivation systems. Unlike open field farmers, however, protected cultivation relies more on the cold-chain facilities, due to the perishability of high-value vegetables. The results are in line with Chand *et al*. (2018) and NITI Aayog (2021) studies which highlighted marketing inefficiencies as a major problem in the vegetable sector.

The overall findings suggest that protected cultivation is more successful in terms of yield, profitability, quality improvement, job creation and off-season production. Compared to open field cultivation, open field cultivation has a higher pest and weed pressure, higher climatic vulnerability, and lower market price realization. Marketing is the most important constraint in both cultivation systems, and this is where suitable policy measures are needed.

4. DISCUSSION

It is observed that there are wide differences in the perceptions of the farmers between protected and open field vegetable cultivation systems in Haryana in terms of prospects, production problems, and marketing constraints. The results add to the current debate on the economic sustainability, technological feasibility and market integration of modern horticultural systems in India and other developing economies.

4.1 Comparative Prospects: Implications for Productivity and Farm Profitability

The study has shown that protected cultivation can be superior to open-field cultivation in terms of agronomic and economic benefits. Farmers under protected systems reported higher Weighted Mean Scores for productivity, quality and off-season cultivation, consistent with empirical results from Israel, China and the Netherlands where controlled-environment agriculture has been found to yield 2 to 5 times more than traditional systems (Dorais, 2019; Li *et al*., 2020).

Cultivation during off-season periods allows farmers to benefit from price premiums, which is a major factor in the profitability of vegetable markets with chronic price volatility.

The quality of the produce obtained under protected conditions is in line with the previous studies conducted in India, which reported improvement in the quality due to micro-climate control, precision fertigation and lower exposure to pests (Kumar *et al*., 2015; Mehta *et al*., 2020). Furthermore, the role of protected cultivation in providing year-round jobs highlights the socio-economic importance of the practice, especially in

rural settings where seasonal unemployment is prevalent.

Open field farming, which requires less investment, is popular, but its future is limited by climatic risks, pest risk, and input quality. This comparative disadvantage is consistent with earlier research on the cultivation of vegetables by smallholders in South Asia (Chand *et al*., 2018).

4.2 Production Constraints: Economic versus Agro-climatic Vulnerabilities

The production constraints faced by farmers are clearly divided between the two cultivation systems. The main constraints faced by protected cultivation farmers are high establishment cost and reliance on skilled labour, frequent technical guidance and structural vulnerability to storm-related damage. The findings are similar to the previous studies conducted in Himachal Pradesh, Punjab and other international greenhouse systems (Pascale *et al*., 2017), where the high initial investment cost is the major constraint for the widespread adoption of protected cultivation despite its long-term profitability. The biological and environmental challenges faced by open field farmers include high weed populations, poor quality seed, climate change-induced losses and heavy infestation by pests and diseases. The results are consistent with the previous studies on open field vegetable production in India which showed that yield uncertainty is closely linked with ecological exposure (NITI Aayog, 2021). These contrasting constraints suggest that technological innovations are not enough. Complementary measures are essential for both protected cultivation and open-field cultivation, including skill development, extension services and climate-resilient structures for the former, and better pest management, quality input provisioning and climate-risk mitigation measures for the latter.

4.3 Marketing Constraints: A Systemic Challenge Across Both Cultivation Methods

The marketing dimension was the most dominant one across both cultivation systems, with the highest Weighted Mean Scores being recorded on the absence of Minimum Support Price (MSP), lack of organized marketing system, price fluctuations, and poor cold storage facilities. The results are in line with the inefficiencies observed in the vegetable marketing chains at the national level such as poor linkages with wholesale mandis, farmers' lack of bargaining power, and poor post-harvest facilities (Azad *et al*., 2019). The protected cultivation farmers grow higher valued crops but still remain in the same institutional marketing system as open field farmers, thus limiting the ability of higher productivity to translate into stable and remunerative incomes. The protected cultivation farmers are at more risk because of the higher financial losses incurred from unsold perishable produce, while the open field farmers are at more risk because of the high transportation costs and inadequate marketing infrastructure. The lack of integrated cold-chain facilities also exacerbates losses in protected cultivation, especially in crops like capsicum, cucumber and tomatoes which are highly perishable. In summary, the results indicate that marketing inefficiencies, not production inefficiencies, are the main constraint to improving farmers' incomes in the vegetable sector in Haryana.

5. CONCLUSION

The study has concluded that protected cultivation is more agronomic and economic potential than open field cultivation as it enhances productivity, improves quality of produce, allows off-season cultivation and provides better employment opportunities. Its broader use is limited, however, by the high cost of establishment, the technical complexity, the lack of skilled workers and the susceptibility of protected structures to the effects of adverse weather conditions. Open-field cultivation is more readily available for farmers, however, is more vulnerable to pest and disease attack, weed infestation, climatic risks and constraints on inputs.

The results also show that marketing problems are experienced in both cultivation systems. Regardless of the production system, farmers' profitability remains constrained due to price instability, lack of Minimum Support Price (MSP) and unorganized marketing channels, and poor post-harvest infrastructure. The study thus underscores the need for efficient marketing systems and institutions if production technologies are to be improved. A comprehensive policy framework that includes financial support, technical advice, infrastructure, and market reforms will be crucial for supporting sustainable and profitable vegetable production in protected and open field systems.

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