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Advancement of Protected Cultivation in Western-Himalayan Region

"A New Dawn for Agriculture"

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Abstract

The North-Western Himalayan region possesses diverse climatic conditions, allowing for various cropping patterns, instead of this, farmers facing multiple challenges due to scattered land and extreme weather events like cold winds, low night temperatures, high rainfall and floods, resulting in crop losses and economic damage. To address these issues, protected cultivation proves to be a vital tool for building economic and environmental resilience among smallholder farmers in the region. It not only provides a great option for producing more nutritious vegetables, especially during off-season, but also bridges gaps in seasonal variations in vegetable consumption, benefiting smallholder farmer economically. Various comparative research inferred that, the protected cultivation significantly extended crop duration, highest fruit weight, increase productivity (3-4 times), greater net return, B:C ratio, minimum incidence of diseases like bacterial wilt and blossom end rot of fruit as compare to open field condition. Thus, provide greater stability and boost farm income, ultimately positively impacting socio-economic condition of the farmers. To increase the adoption of this hi-tech horticulture technology, the Central and State government have implemented various schemes such National Horticultural Mission (NHM) which offers a 50% subsidy for establishing protected cultivation structure and acquiring planting materials for flowers and vegetables; National Horticulture Board (NHB), Mission for Integrated Development of Horticulture (MIDH), Horticulture Mission for North East and Himalayan

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States (HMNEH) as well as projects like HTM and RKVY in hill states have further popularized polyhouse cultivation for high-value vegetables and flowers.

Introduction

India's economy heavily relies on agriculture and approximately 70% of rural households depend on it as their main source of livelihood, with 82% of farmers being small and marginal (FAO, 2023). Hence, the growth of agriculture is closely linked to overall economic well-being. Currently, agriculture and allied sectors contribute 19.0% to the gross value added (GVA) in the Indian economy during 2021-2022, though this share was 14.39% at base prices during 2018-19 (MoSPI, 2023).

Bio-physical and socio-economic characteristics of North-Western Himalayan Region:

The northwestern Himalayan region of India, comprises of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Geographically, it is located between 28°43' to 37°05' N latitude and 72°40' to 81°02' E longitude. It covers an estimate area of approximately 33 million hectares, among which J&K covers 22 million ha, Himachal Pradesh 5 million ha and Uttarakhand about 5 million ha. It constitutes about 10% of the total geographical area of the country, with its hilly terrain, which covers more than two-thirds of its land, leaving only a quarter suitable for cultivation (ISFR, 2011; *Census of India, 2011; #ISFR, 2019). Nevertheless, the adoption of agriculture and allied in these hilly areas, particularly by small and marginal farmers, has brought prosperity due to the adverse agro-climatic conditions, ranging from sub-humid to sub-tropical and dry temperate, which favours the cultivation of various fruits and vegetables. Despite being climate-sensitive, the agriculture and horticulture sectors in these regions offer great opportunities for farmers to cultivate off-season vegetables and diverse fruits and flower crops (Verma *et al.*, 2022) (Kishore *et al.*, 2014). Inspite of its great importance in north-western Himalayan region, the agriculture and allied sector is facing multiple challenges, including globalization, shrinking land resources, scattered land and weather extremities. Despite diverse climatic conditions, offering various cropping patterns, but extreme weather events such as cold wind, low night temperature, high rainfall, high relative humidity, floods and various biotic stresses pose significant for growing high value vegetables and quality seed production in open field conditions. To address these challenges, to meet the growing demand for quality agricultural produce and making

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cultivation successful in these adverse conditions, adopting a unique or specialized hi-tech horticultural technologies becomes essential. One such area is protected cultivation, which is being widely practiced in the developed countries, but its use in India is limited. Moreover, the demand for high-quality hybrid seeds of valuable vegetables grown under protected conditions has been increasing, making protected cultivation a viable and efficient approach in the face of land scarcity and continuous vegetable demand. Now adays farmers also shifting from the traditional agriculture to modern agriculture and diversify the cropping system with high value crops, floriculture, vegetable cultivation etc. to gain more profit per unit (Kaushal and Singh, 2019) (Prakash *et al.*, 2022).

The Central and State government have implemented various schemes to support and promote protected cultivation such as, National Horticultural Mission (NHM) offers a 50% subsidy for establishing protected cultivation structure and acquiring planting materials for flowers and vegetables; National Horticulture Board (NHB), National Horticulture Mission (NHM), Mission for Integrated Development of Horticulture (MIDH) Horticulture Mission for North East and Himalayan States (HMNEH); other projects like HTM and RKVY support protected cultivation hill states have further popularized polyhouse cultivation for high-value vegetables and flowers. This initiative has encouraged farmers to adopt protected cultivation, leading to increased cultivation of horticultural crops in the country.

Protected Cultivation and its importance in north-western Himalayan region:

An innovative approach, "Protected Cultivation" also known as Controlled Environment Agriculture (CEA) is a modern, less environment dependent and capital-intensive hi-tech horticulture technology that offers numerous benefits for farmers such as increased productivity, efficient resource utilization, optimizes land utilization and higher income. Combining horticultural and engineering techniques, protected agriculture optimizes crop production, quality and efficiency, by manipulating factors like temperature, humidity, light, soil, water and fertilizer (Nordey *et al.*, 2017) (Jensen, 2002). Without sufficient storage infrastructure or vegetable processing industry, protected cultivation, particularly in greenhouses allows the cultivation of vegetables in off-seasons, creating a continuous supply of fresh produce and adding value to farmers' output. At global level the area covered under protected cultivation is 275,000 hectares, whereas India covers about 110,000 hectares.

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Potential crops suitable for protected cultivation include a variety of ornamental flowers such as cut rose, carnation, chrysanthemum, gerbera, orchids, anthurium, gypsophila, daisies and lilies along with vegetables like tomato, brinjal, capsicum, cucurbits, lettuce and beans (Yadav, 2018) (Keshwania *et al.*, 2021).

Table1. States of north-western Himalayan region in protected cultivation. (Anonymous, 2014)

State	**Approx. Area under protected cultivation (ha)**	**Crops**
Himachal Pradesh	700	Capsicum, Carnation, Gerbera, Tuberose
Uttarakhand	300	Gerbera, Capsipum
Jammu and Kashmir	<100	For vegetable nursery purpose

Cultivation these crops under Protected conditions specially vegetables have proven to be a highly profitable and flexible technology in the north-western Himalayan region of India. This hi-tech approach can be implemented on both small and large scales, depending on specific needs and available space, providing growers with a reliable means to increase their income during periods outside the regular growing season. There are various types of protected structure such as greenhouses, naturally ventilated polyhouses, insect proof net houses, shade net house, plastic tunnel and mulching, raised beds, trellising and drip irrigation. The choice of protected structure depends on climatic conditions, crop type, season and targeted seed production quantity. (Singh *et al.*, 2016). (Kishore *et al.*, 2014).

Protected cultivation as a vital tool for easier weed management, controlled irrigation, disease reduction, higher plant density, improved quality, provide greater stability as well as increase productivity (3-4 times) and boost farm income especially in vegetable crops as compare to open environment. In addition to these, also provide greater stability and reduced income variability by positively impacting socio-economic condition of the farmers, thus increasing employment opportunities and higher farm and household income for protected growers (Yadav, 2018) (Mehta *et al.*, 2020).

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This fact is corroborated by subsequent studies as well:

A study conducted by (Singh *et al.,* 2011) (Kumar *et al.,* 2021) in Uttarakhand revealed that the use of protected technology significantly extended crop duration with 270 days in polyhouse, 180 days in poly tunnel and 150 days in poly mulching compared to 177 days in open field conditions. The highest fruit weight (2.91 kg/plant) and yield (17.48 kg/m²) were achieved in polyhouse followed by poly tunnel (1.89 kg/plant, 11.34 kg/ m²), poly mulching (1.57 kg/plant, 9.43 kg/ m²) and open field conditions (0.98 kg/plant, 5.90 kg/ m²), respectively. The different protected technologies demonstrated greater net returns (253.84/m² in polyhouse, 132.08/ m² in poly-tunnel, 88.56/ m² in poly-mulching, 37.37/ m² in open field) and B:C ratio of 1.0:4.72 in polyhouse, 1.0:3.68 in poly-tunnel, 1.0:3.03 in poly-mulching and the lowest in open field condition (1.0:2.12). the incidence of bacterial wilt (3.40%) and blossom end rot of fruit (4.32%) was minimal under polyhouse conditions, while it was significantly higher in open field conditions (68.7% and 17.10%), respectively. Moreover, protected cultivation of vegetables contributes to higher yield (40% to 95.5%) as compare to open cultivation and also subsidy scheme as well as FPOs needs to be encouraged, which would help them in seeking better quality of inputs and enhancing negotiating power in the market to realize maximum returns for their farm produce.

Ramasamy *et al.,* (2021) concluded that white and red amaranths had consistently better yields (7.68-19.70 t/ha) when grown in pink-net houses throughout all season, while water spinach yielded better (16.25-20.88 t/ha) in white poly-net houses. They both shows higher levels of neoxanthin, lutein and 2-3fold higher β-carotene levels compare to open fields. Moreover, the pink poly-net house was the highest iron supplier for water spinach in winter. The pink poly-net house could be an excellent option to produce more nutritious vegetables, especially during off-seasons, bridging gaps in seasonal variations in vegetable consumption and benefiting smallholder farmers economically.

Kishore *et al.,* (2014) revealed that under protected condition, cropping sequence of tomato-pea-carrot-cucumber demonstrated the highest production efficiency, yielding the best return of ₹13,336.1/100 m², a B:C ratio of 4.05 and a profitability of 36.53/100 m²/ day. But, cropping sequence of pea-coriander-french beans-bitter gourd was found to be the least profitable. Although the production cost in polyhouses was approximately 1.5 times higher

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than in open fields, the returns were about two times higher. Maitra, et al., 2020 indicated that the feasibility of protected cultivation for off-season vegetables crops has proven to be a profitable agro-enterprise with a high B:C ratio, ranges from 10.58 for off-season coriander leaf to 1.62 for off-season cucumber. Additionally, pest and disease issues in poly-house crops were minimal. Moreover, the cladded and shaded polyhouses contributed to low evaporation rates, allowing the major part of the crop's water requirement to be met from the residual soil moisture.

A study conducted by (Pachiyappan *et al.*, 2022) (Puneraa *et al.*, 2017**)** in Himachal Pradesh indicates that cultivating flowers and vegetables under protected conditions has proven to be highly profitable, despite higher initial investments. Polyhouse cultivation of rose and capsicum in hilly regions incurred significantly higher cultivation cost (300%), gross returns (250%) and net returns (190%) compared to open cultivation. Most crops grown in polyhouses showed high profitability at different discount rates (7%, 10%, 12%) and some crops ere rewarding under shade net conditions with subsidies. The adoption of protected cultivation was significantly influenced by factors like literacy, income, access to subsidies and risk orientation. The cost of protected cultivation can be recovered within 3-5 years with Internal Rate of Return (IRR0 ranging from 31% to 73%. Sensitivity analysis indicates that protected cultivation remains sustainable even without subsidies, increasing income by 65%. However, further expansion of protected cultivation relies on effective supporting institutions and market structures.

Findings of the study conducted in Jammu and Kashmir reveals that, greenhouse technology is still in its developing stage in this state. polyhouse implementation remains at a very early stage with most polyhouses being smaller than 100 m² and farmers primarily use them for raising nurseries, resulting in the production of 7120 mt of vegetables across 286.08 hectaes. While raising seedlings in polyhouses proves beneficial for cultivating off-season vegetables outside, the full-scale adoption of greenhouse technology is not yet widespread in the sampled regions of J&K **(**Sharma, 2017).

Constraints:

Challenges in protected cultivation include associated high expenses, include high basic and operational cost, particularly the substantial initial infrastructure investment (capital

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cost). Moreover, irregular power supply, scarcity of skilled labour, lack technical and practical knowledge in growing crops under protected structures; limited work has been done on designing protected structures for different locations; the quality and availability of cladding materials pose significant challenges in protected cultivation; Repair and maintenance of these materials are also major hurdles due to their expensive short life and limited availability; the cultivation under protected structure faces management challenges of some pests and soil-borne pathogens such as bacterial wilt, downy mildew, collar rot and powdery mildew; Farmers with zero affordability are hesitant to adopt it; In protected cultivation, manual or hand pollination in cross-pollinated vegetables like cucurbits or the development of their parthenocarpic hybrids/varieties can be challenging.

Conclusion:

The shift towards producing high-quality hybrid seeds of valuable vegetables under protected conditions offers additional livelihood opportunities for small, marginal and women farmers. Effective management of protected structures leads to more efficient agricultural inputs and reduced reliance on harmful pesticides. Protected cultivation contributes to supply of off-season vegetables, which can bridge gaps in seasonal variations and promote environmentally friendly production, ultimately leads to high market demand, boost income and livelihood. Though impacts vary by location and crop, piloting protected cultivation can benefit smallholder farmers, addressing challenges from climate change and pest pressure. Comparative studies highlight higher seed yields, quality, healthy produce, minimum insect-pest pressure and higher income in protected conditions, making it a potential future for agriculture.

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