



Popularization of Dragon Fruit Cultivation through Demonstration Units: A Step towards Crop Diversification and Water Conservation

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ABSTRACT

Punjab agriculture is mostly characterized by the rice-wheat cropping system, severely depletes groundwater and reduces the sustainability of production. Crop diversification and the preservation of natural resources can be achieved through the promotion of high-value, water-efficient horticulture crops like dragon fruit. The present study was undertaken to popularize dragon fruit cultivation through the establishment of Dragon Cultivation Demonstration Units (DCDUs) at farmers' fields. A standardized knowledge test was created and verified to evaluate the intervention's efficacy. Using the difficulty index, discrimination index, and point-biserial correlation coefficient, 32 objective items based on the suggested package of practices for dragon fruit production were first created and evaluated psychometrically. Beneficiary farmers were given the validated instrument both before and after the demonstration program to measure changes in their knowledge levels. The results showed that farmers' knowledge significantly improved after the intervention, demonstrating the efficacy of DCDUs as an extension strategy for technology transmission. Additionally, beneficiary farmers expressed positive response on dragon fruit cultivation's profitability, water-use efficiency, climate resilience, and potential for diversification. The DCDUs also generated a significant multiplier effect, with neighbouring farmers visiting the demonstration orchards and several subsequently adopting dragon fruit cultivation. However, high establishment costs and limited availability of quality planting material remained the major constraints to wider adoption. The study concludes that DCDUs are an effective extension strategy for enhancing farmers' knowledge, promoting technology adoption, encouraging crop diversification, and contributing to water conservation in Punjab.

Keywords: Dragon fruit, Dragon cultivation demonstration unit, knowledge assessment, Water conservation, Crop diversification, Farmer Perception, Technology Adoption

INTRODUCTION

Punjab's extensive rice and wheat farming has been crucial to maintaining India's food security. Even though this production system significantly increased national food grain production and agricultural productivity, its long-term continuation has led to serious ecological and environmental problems, such as rapid groundwater depletion, declining soil fertility, decreased factor productivity, and environmental pollution from burning crop residue (Bahga, 2021; Singh, 2023). These concerns have intensified the need to diversify the existing rice-wheat production system towards economically viable, resource-efficient, and climate-resilient agricultural enterprises. A sustainable approach to increasing farm profitability, boosting climate change resilience, reducing production risks, and encouraging effective use of land and water resources is crop diversification (FAO, 2022). High-

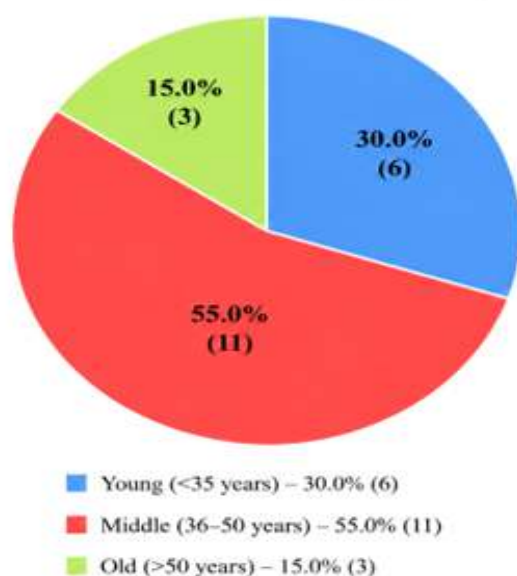
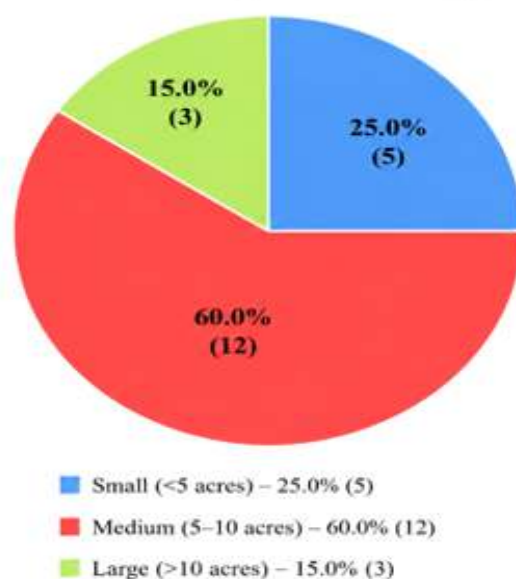
value horticulture crops have significant potential among the existing diversification choices due to their better economic returns, ability to create jobs, and comparatively reduced water requirements when compared to traditional cereal crops. Due to its capacity to adapt to a variety of agroclimatic conditions, resilience to drought and salinity, strong market demand, excellent nutritional composition, and appealing financial returns, dragon fruit (*Selenicereus* spp.) has recently become a potential fruit crop. (Luu *et al*, 2021; Kakade *et al*, 2023). The fruit is becoming more and more well-liked among consumers who are concerned about their health because it is high in dietary fiber, vitamins, minerals, betalains, phenolic compounds, and antioxidants (Chatterjee *et al*, 2024).

Dragon fruit, a Crassulacean Acid Metabolism (CAM) plant, is especially well-suited for water-scarce

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Figure 1. Distribution of beneficiary farmers according to age (n = 20)**Figure 2. Distribution of beneficiary farmers according to land holding (n = 20)**

and semi-arid areas where sustainable water management is a top priority due to its remarkable water-use efficiency through nocturnal stomatal opening (Luu *et al.*, 2021). Recognizing its potential, the Punjab Agricultural University (PAU), Ludhiana, carried out a thorough evaluation of dragon fruit under Punjabi agroclimatic conditions and recommended the cultivars Red Dragon-1 and White Dragon-1 for commercial cultivation, along with standardized production technologies. Large-scale adoption of dragon fruit cultivation is still restricted despite its significant production and market potential due to a lack of technical expertise, high initial establishment costs, uncertainty about production methods, scarcity of high-quality planting material, and weak market connections. Farmers are generally doubtful to adopt newly introduced enterprises unless they are able to observe their performance under local conditions and receive continuous technical guidance and institutional support. Agricultural extension plays a critical role in facilitating the adoption of improved technologies by strengthening farmers' knowledge, skills, and decision-making capacity. Among various extension approaches, demonstration-based extension has been widely recognized as one of the most effective methods for promoting agricultural innovations because it enables farmers to observe recommended technologies under actual field conditions and gain practical experience through experiential learning. Such demonstrations reduce uncertainty, enhance farmers' confidence, and facilitate farmer-to-farmer knowledge

exchange, thereby accelerating the diffusion of innovations within rural communities (Rogers, 2003). On-farm demonstrations have consistently been reported to improve knowledge acquisition, technology adoption, and behavioural change among farmers by providing visible evidence of the technical and economic advantages of recommended practices. With this perspective, 20 Dragon Cultivation Demonstration Units (DCDUs) were established in selected villages of south-western Punjab. Although demonstration-based extension has been successfully employed for promoting several agricultural technologies, empirical evidence regarding its effectiveness in popularizing dragon fruit cultivation under Punjab conditions remains limited. Scientific evaluation of such interventions is essential to assess their contribution towards improving farmers' knowledge, enhancing adoption of recommended production technologies, shaping farmers' perceptions, and promoting sustainable crop diversification. Therefore, the present investigation was undertaken to assess the effectiveness of Dragon Cultivation Demonstration Units in enhancing farmers' knowledge, technology adoption, crop diversification, and water conservation in south-western Punjab.

MATERIALS AND METHODS

Study area

The study was carried out in the Faridkot district of southwest Punjab between 2024 and 2026.

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Table 1. Psychometric validation of pre-intervention the dragon fruit knowledge test.

Item	Difficulty Index (P)	Point-Biserial (rpbis)	Discrimination Index (DI)	Decision
1	0.952	0.051	0.000	Revise/Delete
2	0.905	0.567	0.167	Revise
3	1.000	0.839	0.500	Retain
4	0.952	0.869	0.667	Retain
5	0.952	0.909	1.000	Retain
6	0.952	0.481	0.167	Revise
7	0.857	0.697	0.500	Retain
8	0.905	0.648	0.333	Retain
9	0.905	0.719	0.500	Retain
10	0.905	0.690	0.500	Retain
11	0.952	0.051	0.000	Revise/Delete
12	0.952	0.481	0.167	Revise
13	0.952	0.481	0.167	Revise
14	0.905	0.567	0.167	Revise
15	0.905	0.648	0.333	Retain
16	0.905	0.719	0.500	Retain
17	0.952	0.481	0.167	Revise
18	0.905	0.648	0.333	Retain
19	0.952	0.481	0.167	Revise
20	0.952	0.869	0.667	Retain
21	0.952	0.481	0.167	Revise
22	0.905	0.648	0.333	Retain
23	0.952	0.481	0.167	Revise
24	0.905	0.567	0.167	Revise
25	0.905	0.719	0.500	Retain
26	0.905	0.567	0.167	Revise
27	0.952	0.481	0.167	Revise
28	0.952	0.481	0.167	Revise
29	0.905	0.567	0.167	Revise
30	0.952	0.481	0.167	Revise
31	0.952	0.481	0.167	Revise
32	0.952	0.481	0.167	Revise

The district is known for its semi-arid environment, little rainfall, and rising groundwater depletion. At an average elevation of around 210 meters above mean sea level, the Faridkot district is located between latitudes 30°40' and 30°55' N and longitudes 74°40' and 75°20' E. The area has a semi-arid environment with scorching summers, chilly winters, and 400–450 mm of annual rainfall on average, the majority of which falls during the southwest monsoon season.

Research design and sampling

An ex-post facto research design was adopted as the extension intervention had already been implemented prior to data collection. Twenty villages were selected for establishing where Dragon Cultivation Demonstration units. One beneficiary farmer from each demonstration unit was selected,

resulting in a sample of 20 respondents. Beneficiaries were identified in consultation with scientists of Punjab Agricultural University, Agricultural Technology Management Agency (ATMA), Krishi Vigyan Kendra (KVK), and Farm Advisory Service Centres (FASCs). Farmers were selected based on their willingness to establish demonstration units, availability of suitable land, and readiness to serve as local resource persons for technology dissemination. The selected farmers represented different villages of Faridkot district, enabling wider geographical coverage and facilitating farmer-to-farmer dissemination of the technology.

Extension intervention

Each selected farmer established Dragon Cultivation Demonstration Unit following the package of practices recommended by Punjab Agricultural University. Beneficiaries received quality planting

Table 2. Item-wise psychometric properties of the pre-intervention dragon fruit knowledge test (n = 20)

Item	Difficulty Index (P)	Difficulty Level	Point-Biserial (rpbis)	Interpretation	Discrimination Index (DI)	Decision
1	0.952	Very Easy	0.051	Very Poor	0.000	Revise/Delete
2	0.905	Very Easy	0.567	Good	0.167	Revise
3	1.000	Extremely Easy	0.839	Excellent	0.500	Retain
4	0.952	Very Easy	0.869	Excellent	0.667	Retain
5	0.952	Very Easy	0.909	Excellent	1.000	Retain
6	0.952	Very Easy	0.481	Good	0.167	Revise
7	0.857	Easy	0.697	Very Good	0.500	Retain
8	0.905	Very Easy	0.648	Very Good	0.333	Retain
9	0.905	Very Easy	0.719	Very Good	0.500	Retain
10	0.905	Very Easy	0.690	Very Good	0.500	Retain
11	0.952	Very Easy	0.051	Very Poor	0.000	Revise/Delete
12	0.952	Very Easy	0.481	Good	0.167	Revise
13	0.952	Very Easy	0.481	Good	0.167	Revise
14	0.905	Very Easy	0.567	Good	0.167	Revise
15	0.905	Very Easy	0.648	Very Good	0.333	Retain
16	0.905	Very Easy	0.719	Very Good	0.500	Retain
17	0.952	Very Easy	0.481	Good	0.167	Revise
18	0.905	Very Easy	0.648	Very Good	0.333	Retain
19	0.952	Very Easy	0.481	Good	0.167	Revise
20	0.952	Very Easy	0.869	Excellent	0.667	Retain
21	0.952	Very Easy	0.481	Good	0.167	Revise
22	0.905	Very Easy	0.648	Very Good	0.333	Retain
23	0.952	Very Easy	0.481	Good	0.167	Revise
24	0.905	Very Easy	0.567	Good	0.167	Revise
25	0.905	Very Easy	0.719	Very Good	0.500	Retain
26	0.905	Very Easy	0.567	Good	0.167	Revise
27	0.952	Very Easy	0.481	Good	0.167	Revise
28	0.952	Very Easy	0.481	Good	0.167	Revise
29	0.905	Very Easy	0.567	Good	0.167	Revise
30	0.952	Very Easy	0.481	Good	0.167	Revise
31	0.952	Very Easy	0.481	Good	0.167	Revise
32	0.952	Very Easy	0.481	Good	0.167	Revise

material of the recommended cultivars (Red Dragon-1 and White Dragon-1), reinforced cement concrete (RCC) support structures, technical literature, and continuous advisory services. Capacity-building activities included on-campus and on-farm training programmes, field demonstrations, exposure visits, farmer–scientist interactions, diagnostic field visits, and field days. These interventions were designed to improve farmers' knowledge, technical skills, confidence, and adoption of scientific dragon fruit production technologies.

Development and standardization of the knowledge test

A knowledge test was developed to assess farmers' knowledge regarding recommended dragon

fruit production technologies. Initially, 60 objective-type items covering all major aspects of dragon fruit cultivation, including varieties, planting, support systems, irrigation, nutrient management, pruning, pest and disease management, harvesting, and post-harvest practices, were prepared after an extensive review of literature, consultation with subject matter specialists, and recommendations of Punjab Agricultural University. Following expert scrutiny for content validity, 32 items were retained for empirical testing. The items consisted of multiple-choice, dichotomous (Yes/No and True/False), and fill-in-the-blank questions. Each correct response was assigned a score of one, while incorrect responses received a score of zero.

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Pre-testing and psychometric validation

1. Pre-testing of the items was done as suggested by Gonard (1948) by administering all the 32 questions to 20 beneficiary farmers in nonsample area. The scores allotted were '1' for correct response and '0' for incorrect response. After computing total scores obtained by each of the 20 respondents on 32 items, they were arranged in the descending order. Then the respondents were divided into six equal groups of five members each and were labelled as G1, G2, G3, G4, G5 and G6. For the purpose of item analysis the middle two groups G3 and G4 were eliminated keeping only four extreme groups with high and low scores.

The psychometric properties of each item were evaluated using three standard criteria:

1. Difficulty Index (P): The difficulty index indicates the proportion of respondents answering an item correctly and was computed as

Difficulty index = Number of farmers answered correctly/Total number of beneficiaries

2. Discrimination Index (DI): of each of the items were computed by using the following formula.

$$E^{1/3} = \frac{(S1+S2) - (S5+S6)}{N/3}$$

Where, S1, S2, S5 and S6 are the frequencies of correct answers in groups G1, G2, G5 and G6, respectively and N is the total number of respondents in the sample selected for items analysis (60). The value of the discrimination index for the knowledge items on production technology with special emphasis on sustainable cultivation practices in groundnut ranging from 0.2 to 0.8 were considered for the final selection of knowledge test for same reasons explained under item difficulty index.

Point-Biserial Correlation (rpbis): Point-biserial correlation coefficients were calculated to assess the relationship between individual item scores and the total test score. Items exhibiting positive and statistically acceptable coefficients were retained, whereas items showing negative or very low correlations were revised or discarded.

Point biserial correlation (rpbis) is the test validation in which the criterion of validity is considered to be internally consistent. That is, the relationship of the total score to a dichotomized response to any given item. An item by item

computation of point biserial correlation was calculated by using the formula suggested by Garrett (1966).

$$rpbis = \frac{M_p - M_q}{\sqrt{PQ}} \times \frac{SD}{\sqrt{PQ}}$$

Where,

r pbis = point biserial correlation coefficient

MP = Mean of the total scores of the respondents who answered the item correctly

MQ = Mean of the total scores of the respondents who answered the item incorrectly

SD = Standard deviation of entire sample

p = Proportion of respondents giving correct answer to the item

q = Proportion of respondents giving incorrect answer to the item

q = 1 – p

X = Total score of the respondents for all items

Y = Response of the individual for the items

XY = Total score of the farmers multiplied by the response of the individual to the item.

Based on the combined values of Difficulty Index, Discrimination Index, and Point-Biserial Correlation, poorly performing items were either modified or deleted before finalizing the knowledge test. The validated instrument was subsequently used for assessing farmers' knowledge before and after the extension intervention.

Data collection

The primary data were collected through personal interview using a pre-tested and structured interview schedule. Information relating to socio-economic characteristics, knowledge of recommended dragon fruit cultivation practices, adoption behaviour, farmers' perceptions, constraints, and future expansion plans was collected. Secondary information on demonstration units, training programmes, and extension activities was obtained from project records maintained at the Regional Research Station, Faridkot.

Measurement of variables

Knowledge gain was estimated by comparing farmers' knowledge scores before and after the intervention. Adoption of recommended cultivation practices was assessed based on the extent to which respondents implemented the package of practices recommended by Punjab Agricultural University. Farmers' perceptions regarding dragon fruit cultivation were measured using a structured perception scale, while constraints were ranked according to the frequency of responses.

Statistical analysis

The collected data were coded, tabulated, and analysed using Microsoft Excel and IBM SPSS Statistics. Descriptive statistical measures, including frequency, percentage, mean, weighted mean score, and rank order, were employed to summarize the data. Knowledge gain was estimated using percentage change in knowledge scores before and after the intervention. The psychometric properties of the knowledge test were evaluated through Difficulty Index, Discrimination Index, and Point-Biserial Correlation following standard procedures for knowledge test construction. The findings were interpreted to assess the effectiveness of Dragon Cultivation Demonstration Units in improving farmers' knowledge, promoting technology adoption, encouraging crop diversification, and supporting water conservation in south-western Punjab.

RESULTS AND DISCUSSION

Socio-economic profile of beneficiary farmers

The socio-economic characteristics of the beneficiary farmers are presented in Table 1. The respondents were predominantly middle-aged farmers (55.0%), followed by young farmers below 35 years (30.0%) and older farmers above 50 years (15.0%). Regarding educational status, half of the respondents had completed secondary or higher secondary education, while 25.0% were graduates, indicating a favorable educational background for understanding and adopting improved agricultural technologies. In terms of landholding, the majority of farmers (60.0%) possessed medium-sized holdings (5–10 acres), whereas 25.0% and 15.0% belonged to small and large farm categories, respectively. The predominance of medium-sized landholders suggests that dragon fruit cultivation is particularly attractive to farmers seeking to diversify their farming systems with high-value horticultural crops without requiring extensive land

resources. Overall, the socio-economic profile indicates that the beneficiaries were progressive farmers with moderate educational attainment and adequate land resources, characteristics that favour the adoption of improved agricultural technologies. These findings are in agreement with previous studies, which reported that education, farming experience, and farm size positively influence farmers' participation in extension programmes and the adoption of innovative agricultural technologies.

Psychometric validation of pre-intervention the dragon fruit knowledge test

The psychometric properties of the pre-intervention dragon fruit knowledge test are presented in Table 1. The quality of each item was evaluated using the difficulty index (P), point-biserial correlation (rpbis), and discrimination index (DI).

A total of 32 objective-type knowledge items covering recommended dragon fruit production technologies were initially developed through an extensive review of literature, Punjab Agricultural University recommendations, and consultation with subject matter specialists. The items were subjected to psychometric evaluation using the difficulty index (P), discrimination index (DI), and point-biserial correlation coefficient (rpbis) following standard procedures for knowledge test construction. The difficulty index ranged from 0.15 to 0.80, indicating adequate variability in item difficulty. Most of the items (62.5%) exhibited moderate difficulty (0.31–0.70), which is considered desirable for knowledge assessment because such items effectively differentiate respondents possessing different levels of knowledge. Two items were classified as very difficult ($P = 0.15$), while two items were categorized as easy ($P \geq 0.70$). The point-biserial correlation coefficient ranged from -0.449 to 0.508 . Positive coefficients indicated that the respective items were positively associated with the overall knowledge score and measured the intended construct effectively, whereas negative coefficients suggested ambiguity or poor item functioning requiring revision or deletion. Similarly, the discrimination index varied from -0.40 to 0.80 . Items with discrimination values of 0.40 – 0.80 effectively distinguished respondents possessing higher knowledge from those with lower knowledge, whereas items exhibiting negative or zero discrimination were considered unsuitable. Based on the combined evaluation of difficulty index, point-

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biserial correlation coefficient, and discrimination index, 14 items satisfied all psychometric criteria and were retained, 12 items were revised, and 6 items were deleted due to poor psychometric performance. The retained items demonstrated acceptable difficulty, positive item-total correlation, and satisfactory discrimination, confirming their suitability for inclusion in the final knowledge test.

Establishment of Dragon Cultivation Demonstration Units

Twenty Dragon Cultivation Demonstration Units (DCDUs) were established in selected villages of Faridkot district following the package of practices recommended by Punjab Agricultural University (Fig. 1). Beneficiary farmers received quality planting material of Red Dragon-1 and White Dragon-1 cultivars, reinforced cement concrete (RCC) support structures, technical literature, and continuous advisory services. Capacity-building activities included on-campus and on-farm training programmes, field demonstrations, exposure visits, farmer-scientist interactions, field days, and regular diagnostic visits. These interventions enabled farmers to acquire practical skills related to orchard establishment, irrigation scheduling, fertigation, pruning, canopy management, and pest and disease management. The demonstration orchards also served as field learning centres facilitating farmer-to-farmer dissemination of recommended technologies.

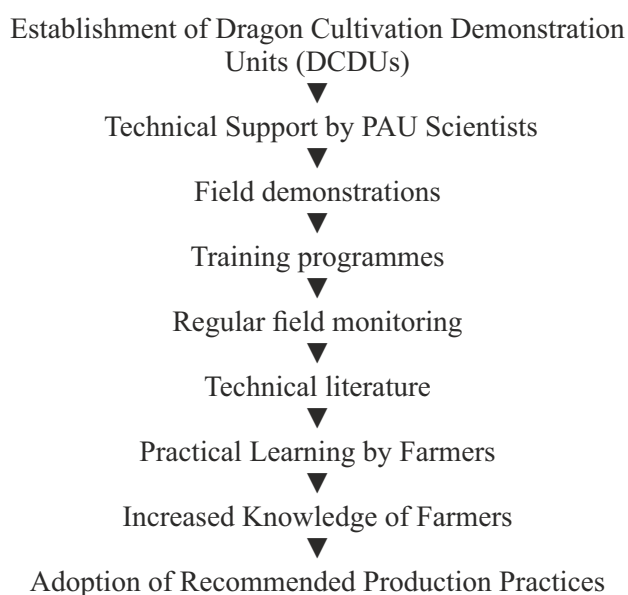


Figure 3. Flow chart illustrating the establishment and impact pathway of Dragon Cultivation Demonstration Units (DCDUs)

Psychometric properties of the post-intervention knowledge test

The psychometric properties of the post-intervention knowledge test are presented in Table 2. Following exposure to Dragon Cultivation Demonstration Units, the difficulty index increased substantially, ranging from 0.857 to 1.000, with an average value of approximately 0.93. These values indicate that almost all respondents answered the majority of questions correctly after the intervention, reflecting a considerable improvement in technical knowledge. The point-biserial correlation coefficient ranged from 0.051 to 0.909. Several items exhibited excellent item-total correlations (≥ 0.80), demonstrating strong internal consistency and confirming that the items effectively measured farmers' knowledge regarding recommended dragon fruit cultivation practices. The discrimination index ranged from 0.000 to 1.000. Although several items showed relatively lower discrimination values, this reduction was primarily attributed to the ceiling effect because most respondents correctly answered nearly all questions after receiving training. Nevertheless, thirteen items demonstrated satisfactory discrimination and were retained for subsequent use. Overall, the post-intervention psychometric evaluation confirmed that the knowledge test effectively measured learning outcomes and documented the substantial improvement in farmers' knowledge following the demonstration programme.

Farmers' perception, constraints and scaling-up impact

Beneficiary farmers developed highly favourable perceptions regarding dragon fruit cultivation (Table 3). All respondents considered dragon fruit a crop possessing high market demand and premium price, while 95 per cent recognized its low irrigation requirement and expressed willingness to recommend the crop to other farmers. Most respondents also acknowledged its profitability, suitability for saline soils, and long productive life. Despite these encouraging perceptions, farmers identified high establishment cost, limited availability of quality planting material, inadequate technical expertise, and marketing uncertainty as the major constraints limiting wider adoption. The demonstration programme generated a significant scaling-up effect. Five beneficiary farmers expanded

Table 3. Farmers' perception, constraints and scaling-up impact of Dragon Cultivation Demonstration Units (DCDUs) (n = 20)

Component	Item	Response (%) / Number	Rank
Farmers' perception	High market demand and premium selling price	100	I
	Low irrigation requirement	95	II
	Willingness to recommend the crop to other farmers	95	II
	Suitable for saline and marginal soils	90	III
	Better profitability than conventional crops	90	III
	Long productive life of plantation	85	IV
	Willingness to expand cultivation in future	85	IV
	Low labour requirement after establishment	80	V
	High initial investment	85	I
Major constraints	Limited availability of quality planting material	75	II
	Lack of local technical expertise	65	III
	Limited awareness among farmers	60	IV
	Marketing uncertainty	45	V
	Labour requirement during establishment	35	VI
Scaling-up impact	Beneficiary farmers expanding cultivation area	25% (5 farmers)	—
	Beneficiary farmers maintaining original cultivation area	75% (15 farmers)	—
	Neighbouring farmers visiting DCDUs	100 farmers	—
	New neighbouring farmers adopting dragon fruit cultivation	25% (5 farmers)	—

the area under dragon fruit cultivation, nearly one hundred neighbouring farmers visited the demonstration orchards, and five neighbouring farmers subsequently established dragon fruit plantations after observing crop performance under local conditions.

Legend: Ranking was based on the proportion of respondents reporting each perception or constraint. Items with the highest response percentage were assigned Rank I, followed by descending order of percentages. Identical percentages received the same rank. Ranking was not applied to the scaling-up impact indicators because they represent descriptive outcomes rather than comparable perception or constraint items.

CONCLUSION

The present investigation demonstrated that Dragon Cultivation Demonstration Units constitute an

effective extension strategy for enhancing farmers' knowledge and promoting adoption of scientific dragon fruit cultivation practices. The substantial increase in post-intervention knowledge scores demonstrates the effectiveness of experiential learning through field demonstrations. Demonstration-based extension enables farmers to observe technologies under real farming situations, thereby reducing uncertainty, improving confidence, and accelerating technology adoption. The high adoption of recommended production technologies observed in the present study further confirms that practical demonstrations supported by continuous technical guidance enhance farmers' willingness to adopt innovative horticultural enterprises. Being a Crassulacean Acid Metabolism (CAM) crop, dragon fruit possesses exceptional water-use efficiency and therefore represents a suitable alternative to the water-intensive rice-wheat production system. The demonstration programme also produced a measurable multiplier effect through farmer-to-farmer

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dissemination, whereby neighbouring farmers adopted dragon fruit cultivation after observing successful demonstration orchards. Although the intervention achieved encouraging outcomes, high establishment cost, inadequate availability of quality planting material, and limited technical support remain important constraints requiring institutional attention. Therefore, strengthening quality nursery production, providing financial assistance for orchard establishment, improving extension services, and developing organized marketing systems will be essential for large-scale adoption of dragon fruit cultivation in Punjab.

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