

Bridging yield gaps in *Brassica napus* L. through cluster frontline demonstrations in south-western region of Punjab

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Received: 07 October 2025

Revised: 03 February 2026

Accepted: 15 April 2026

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Abstract

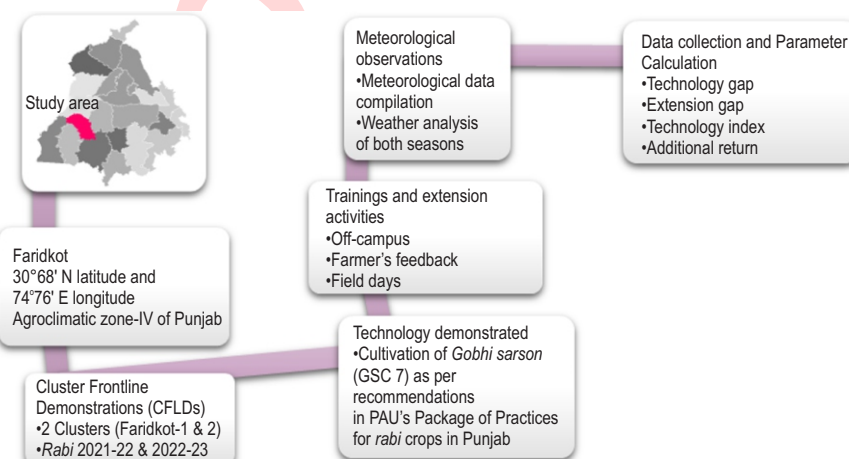
Aim: The present investigation was conducted to study the impact of cluster frontline demonstrations (CFLDs) on production of *gobhi sarson* (*Brassica napus* L.) in two clusters of Faridkot district of Punjab by Krishi Vigyan Kendra. The main objective was to find technology and extension gaps in adoption of technology in rapeseed mustard.

Methodology: The CFLDs were laid out in adopted villages of two clusters of Faridkot district for two consecutive rabi seasons (2021-22 and 2022-23). In frontline demonstration, improved variety of *gobhi sarson*, i.e., GSC 7 was sown as per recommendations in PAU's Package of Practices for *rabi* crops in Punjab.

Results: The mean frontline demonstration yield was 16.1 q ha⁻¹ and 16.3 q ha⁻¹ which were 5.9% and 5.1% higher than farmer's field yield (15.2 q ha⁻¹ and 15.5 q ha⁻¹) during rabi seasons 2021-22 and 2022-23. The mean technology gap (6.2 q ha⁻¹, 6.0 q ha⁻¹), extension gap (1.0 q ha⁻¹, 0.9 q ha⁻¹) and technology index (27.8, 26.9) were observed during 2021-22 and 2022-23, respectively. The higher value of technology index could be due to heat stress conditions during 2021-22. The net returns from frontline demonstration plots were 28.5% and 16.4% higher than farmer's field with 2.0 and 2.2 benefit cost ratio giving additional returns of Rs 11167.5 and Rs 6564 during 2021-22 and 2022-23, respectively.

Interpretation: Adoption of PAU's package of practices can help in adapting weather extremes like heat stress. Region specific package of practices should be prepared in line with weather variability and yield gaps.

Key words: CFLD, Extension gap, Net return, Rapeseed, Technology gap, Technology index



Introduction

Punjab is recognised as the “Granary of India,” as it had fundamental role in success of the Green Revolution in the 1960s. Yet, the disproportionate dependence on the rice–wheat cropping system (>80% of the net sown area) has caused ecological and economic challenges including severe groundwater depletion, excess crop residue management, deteriorating soil health and reduced profitability (Sindhu et al., 2024). The concerns regarding lack of crop diversification arose with declining profitability in vicious rice–wheat rotation in the green revolution states. As a result, urgent action was needed to diversify crops and promote technological innovations that would enable farmers to adopt suitable alternatives (Dutta, 2012). The crop shifts mainly take place due to governmental policies and thrust on some crops over a stipulated time, e.g. establishment of Technology Mission on Oilseeds in 1986 to give thrust on oil seeds production as a national need for the country's requirement for less dependency on imports (Reddy and Suresh, 2009). National Mission on Oilseeds and Oil palm (NMOOP) was started in 2014-15 for oilseeds and oil palm development programme in India and continued up to 2017-18. Later, National Food Security Mission (NFSM) and NMOOP were merged under revamped NFSM from the year 2018-19.

Rapeseed and mustard form major part of edible oilseed crops. They include diverse range of species including Indian mustard or raya (*Brassica juncea* L.), oilseed rape or gobhi sarson (*Brassica napus* L.), Ethiopian mustard (*Brassica carinata* L.), Indian rape or toria (*Brassica rapa* L. var. *Toria*), brown sarson (*Brassica rapa* L. var. *Brown sarson*), yellow sarson (*Brassica rapa* L. var. *Yellow sarson*), black mustard (*Brassica nigra* L.) and taramira (*Eruca sativa* L.) (Chauhan et al., 2011). In India, the oilseed crops were grown on 30.19 million hectares area, yielding 39.67 million tonnes in 2023-24. The total area and production of oilseed in India have increased up to 21.8 and 25.8 per cent since 2018-19. The productivity of oilseed has increased from 1271 Kg ha⁻¹ in 2018-19 to 1314 kg ha⁻¹ in 2023-24. Out of major oilseed crops, rapeseed and mustard were grown on 9.183 million hectare area, yielding 13.26 million tonnes in 2023-24.

The total area and production of rapeseed and mustard in India have increased up to 50.0 and 43.2 per cent since 2018-19 (Indiastat, 2025). In Punjab, the production reached 87,000 tonnes from 49,000 hectares, with a higher productivity of 1777 kg ha⁻¹ during 2024-25 (Indiastat, 2025). However, the productivity of this crop remains low as compared to the global average of about 2000 kg ha⁻¹ (Directorate of Economics and Statistics, 2023). Late sowing after rice and cotton and intercropping with wheat often expose mustard to terminal heat stress during the reproductive stage, reducing metabolic activity and yield. As temperature strongly governs plant phenology, heat stress at seedling and seed filling stages cause stunted growth and poor development. With changing climate and rising temperatures, such late-planted crops are likely to face greater yield loss, necessitating improved adaptive management strategies for sustaining productivity (Brar et al., 2022). Adoption of improved technologies in rapeseed–mustard can enhance its economic viability (Sharma and Thomas, 2013). In

India, a substantial yield gap exists between research stations, on-farm demonstrations, and farmers' fields, and narrowing this gap is crucial for rapidly increasing the productivity (Kumbhare et al., 2025).

Lack of awareness of new production technologies limits oilseed productivity. To address this, the Government of India promotes Cluster Frontline Demonstrations (CFLD) on farmer's fields, following learning by doing approach (Matharu and Tanwar, 2019). They are very important to showcase the potential of advanced technologies (improved varieties, plant protection, weed management etc.) in farmer's fields. Also, it is equally important to identify gaps in their adoption (Singh et al., 2025). In line with mandate of the Krishi Vigyan Kendra (KVKs), i.e., application of technology through assessment, refinement and demonstration of proven technologies under different 'micro farming' situations in a district (Das, 2007), cluster field demonstrations (CFLDs) on oil seeds were conducted to find technology and extension gaps in adoption of technology in rapeseed mustard.

Materials and Methods

Study area: The present investigation was conducted to study the impact of cluster frontline demonstrations (CFLDs) on production of gobhi sarson (*Brassica napus* L.) in Faridkot district of Punjab by Krishi Vigyan Kendra. Faridkot (30°40' N latitude and 74°44' E longitude, 200 m above mean sea level) is a part of South-Western region of Punjab having semi-arid climate and falls under Agroclimatic zone – IV of Punjab. In general, this region is categorised with hot and dry weather having short rainy season. Temperature remains high from April to June. The annual rainfall is 420 mm, out of this >70 per cent is received during southwest monsoon season (June–September). The period from second fortnight of September to October (post monsoon season) experience low rain showers. The cold season remains between November and March. The soil of the district is sandy loam in texture.

Cluster frontline demonstrations (CFLDs) details: The CFLDs were laid out in adopted villages of two clusters of Faridkot (1 and 2) district for two consecutive rabi seasons (2021-22 and 2022-23). Faridkot-1 consisted of 24 villages and cluster-2 of 20 villages. A total area of 10 and 20 hectares during 2021-22 and 2022-23, respectively covered under cluster frontline demonstration (Table 1). The farmers were selected from the adopted villages through a participatory approach, ensuring active involvement of farmers in the study. The crop was grown as per recommendations in PAU's Package of Practices for rabi crops in Punjab. A training programme was arranged for farmers to train about recommended technologies to be demonstrated, and then critical input was provided.

Technology demonstrated: In frontline demonstration, the quality seeds of improved variety of gobhi sarson, i.e., GSC 7, recommended dose of fertilizers, crop pest (weed, insect and disease) management techniques were demonstrated on the farmer's field through CFLD at different locations (Table 2). Local

Table 1: Number of demonstrations of oilseeds

Year	Crop	No. of demonstrations	Area under demonstration (ha)
2021-22	Gobhi sarson	25	10
2022-23	Gobhi sarson	25	20

Table 2: Details of intervention in demonstration fields and farmers' practices

Particulars	CFLD	Farmer's fields
Variety	GSC 7	Local
Time of Sowing	20 th -30 th October	1 st week of November
Method of sowing	Line sowing	Broadcasting
Seed rate (Kg ha ⁻¹)	1.5 kg acre ⁻¹	2.0 kg acre ⁻¹
Thinning and gap filling	At 25-30 DAS	35-40 DAS
Nutrient Management (Kg ha ⁻¹)	Nitrogen – 40 kg acres ⁻¹ Phosphorus – 12 kg acres ⁻¹ Source – Urea and SSP	Nitrogen – 45 kg acres ⁻¹ Phosphorus – 15 kg acres ⁻¹ Source – Urea and DAP
Weed management	Hand weeding at 3-4 weeks after sowing	Nil
Insect and disease management	Adoption of Integrated pest management (IPM) approach Ridomil Gold @ 250g 100 l ⁻¹ per acre Actara 25 WG @ 40g 100 l ⁻¹ per acre	Use of unrecommended fungicides/insecticides

checks (Farmer's practice) were maintained as per conventional practices. KVK scientists regularly visited the sites so that the frontline demonstrations were conducted under their keen observation and supervision.

Trainings and extension activities: Off campus trainings and field days were arranged at CFLD site for its extension to other farmers of the area. The farmer's viewpoint about technologies used under frontline demonstration was collected.

Meteorological observations: The meteorological data, with respect to maximum and minimum temperature, morning and evening relative humidity, rainfall and sunshine hours for the study years of Faridkot was collected from the Meteorological observatory located at Regional Research Station, Faridkot. The observatory is equipped with advanced meteorological instruments such as Single Stevenson Screen (containing maximum, minimum, dry bulb and wet bulb thermometers), Ordinary Rain Gauge, Open Pan Evaporimeter, Soil Thermometer (05 cm, 10 cm and 20 cm soil depth), Anemometer, Wind Vane, and a Campbell Stroke Sunshine Recorder has been established at this station. Besides, automatic weather station (AWS) with advanced sensors is also functioning for recording daily weather parameters.

Statistical analyses: Descriptive statistics for the various meteorological parameters was carried out. Weekly temperature deviation was calculated using following the formula:

$$\text{Deviation in maximum temperature (Tmax)} = \text{Tmax}_{2021-22} - \text{Tmax}_{2022-23} \quad (1)$$

$$\text{Deviation in minimum temperature (Tmin)} = \text{Tmin}_{2021-22} - \text{Tmin}_{2022-23} \quad (2)$$

The data collected from CFLD fields as well as from farmer's field was used to calculate the technology gap, extension gap, technology index and additional return were calculated as formulae (3-6) given by Samui *et al.* (2000).

Results and Discussion

The descriptive statistics of studied weekly meteorological parameters during 2021-22 and 2022-23 at Faridkot are presented in Table 3. During 2021-22, the range of various weekly meteorological parameters *viz.*, maximum temperature (13.2-41.7°C), minimum temperature (6.3-25.6°C), morning relative humidity (48-97%), evening relative humidity (19.1-81.7%), sunshine hours (0-9.1 hrs day⁻¹), rainfall (0-56.2 mm) and evaporation (3.2-63.5 mm) were recorded. The maximum temperature ranged between 13.3°C and 36.0°C, while the minimum temperature ranged from 2.7°C to 22.4°C during 2022-23 at Faridkot (Fig. 2 and 3). Morning relative humidity was observed in the range of 51.3% to 97% and evening relative humidity ranged from 17.4% to 76.4%. Sunshine hours spanned from 1.0 to 9.8 hr per day, rainfall varied from 0 to 46.2 mm and evaporation ranged between 2.4 to 50.4 mm, respectively.

The cumulative sunshine hours during 2021-22 were 1297.7 hrs and 1223.5 hrs in 2022-23. The total recorded rainfall was 134.4 mm and 129.4 mm during 2021-22 and 2022-23 at Faridkot. Distribution of rainfall was uneven across the seasons; during 2021-22, it was observed between the 1st and 5th standard meteorological weeks (SMWs), while in 2022-23, it occurred

Table 3: Descriptive statistics of weekly meteorological parameters during rabi 2021-22 and 2022-23 at Faridkot

Location	Faridkot			
Meteorological parameter	Maximum	Minimum	Mean	Standard Deviation
Rabi 2021-22				
Maximum temperature (°C)	41.7	13.2	26.9	8.2
Minimum temperature (°C)	25.6	6.3	14.6	6.5
Morning relative humidity (%)	97.0	48.0	84.5	13.6
Evening relative humidity (%)	81.7	19.1	43.5	17.2
Rainfall (mm)	56.2	0.0	4.5	12.0
Sunshine hours(hours)	9.1	0.0	6.1	2.3
Evaporation (mm)	63.5	3.2	22.0	18.1
Rabi 2022-23				
Maximum temperature(°C)	36.0	13.3	26.0	6.3
Minimum temperature (°C)	22.4	2.7	13.3	5.2
Morning relative humidity (%)	97.0	51.3	86.3	10.2
Evening relative humidity (%)	76.4	17.4	43.5	14.5
Rainfall (mm)	46.2	0.0	4.3	10.5
Sunshine hours(hours)	9.8	1.0	5.8	2.2
Evaporation (mm)	50.4	2.4	18.5	12.1



Fig. 2: Weekly temperature (maximum and minimum) and relative humidity (morning and evening) during crop duration in 2021-22 and 2022-23 at Faridkot.

predominantly between the 9th and 16th SMWs. Specifically, Faridkot received higher amount of rainfall (110.0 mm) in January 2022, contrasting with 0.8 mm in January 2023. Notably, 68.0 mm of rainfall occurred in March during 2023, whereas no rainfall (0.0 mm) was recorded in 2022. Higher amount of rainfall (46.4 mm) in April 2023, contrasting with 1.4 mm in April 2022. Average maximum

temperature deviation of 6.7°C and minimum temperature deviation of 5.8°C was found from 11 to 17 SMWs (Fig. 4).

Maximum deviation of 8°C in temperature was observed during 7-13 April, 2022 in Punjab. In India, March and April 2022 were the hottest on record, with extreme temperatures

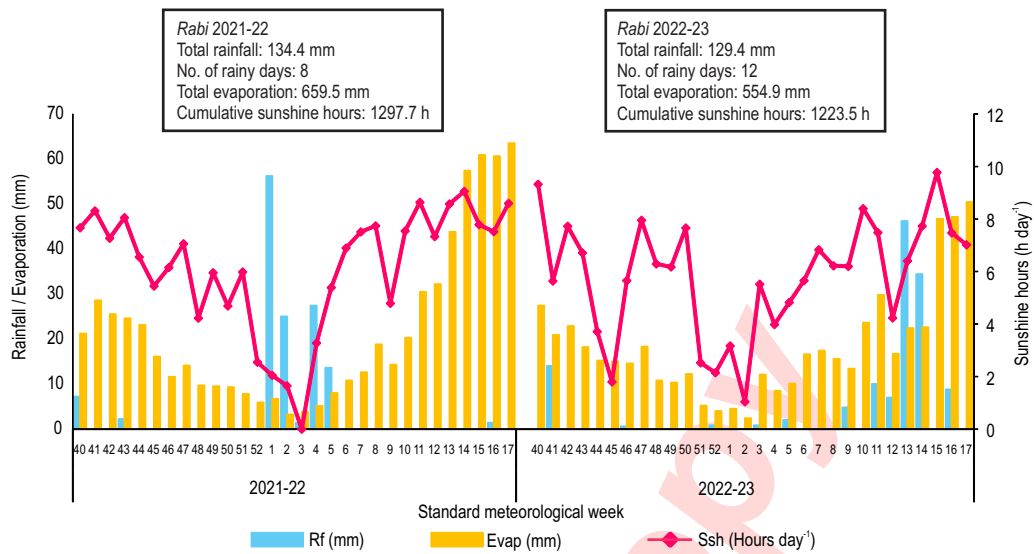


Fig. 3: Weekly total rainfall, total evaporation and mean sunshine hours during crop duration in 2021-22 and 2022-23 at Faridkot.

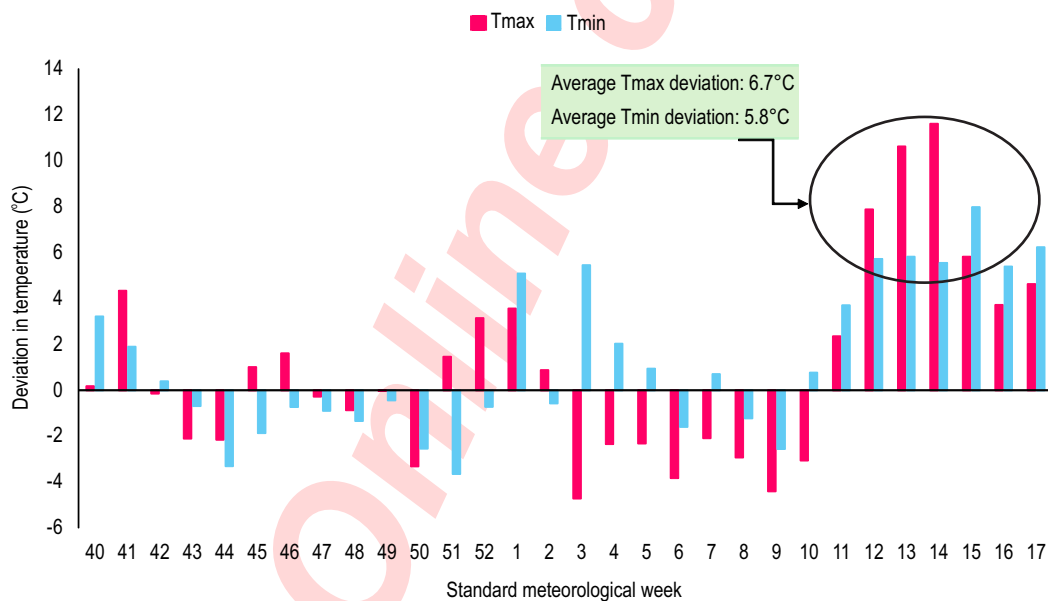


Fig. 4: Maximum and minimum temperature deviation between 2021-22 and 2022-23 at Faridkot.

surpassing normal levels by +8 to +10.8°C and rainfall decreasing by 60 to 99% in 10 out of 36 meteorological subdivisions. This period stands as a stark example of how elevated temperatures and reduced rainfall collectively impacted agricultural production, particularly in the northern and central India. The heat wave struck during these months ultimately reduce crop yields (Bal et al., 2022). The potential yield for GSC 7 was 22.3 q ha⁻¹ as per PAU's Package of Practices for rabi crops in Punjab. In Faridkot-1 cluster, demonstration average yield was

16.6 q ha⁻¹, while it was 15.6 q ha⁻¹ in Faridkot-2 cluster during rabi 2021-22 (Fig. 5). The farmer's field average yield was higher (15.3 q ha⁻¹) in Faridkot-1 than Faridkot-2 (15.0 q ha⁻¹). In rabi 2022-23, the frontline demonstration average yield was observed less (16.1 q ha⁻¹) than 2021-22 in Faridkot-1 cluster, while it was higher (16.5 q ha⁻¹) the in case of Faridkot-2 cluster. The farmer's field average yield was almost stable (15.4 q ha⁻¹) during rabi 2022-23 while it was higher (15.5 q ha⁻¹) in the case of Faridkot-2 cluster. Demonstration plots were observed lower seed yield than

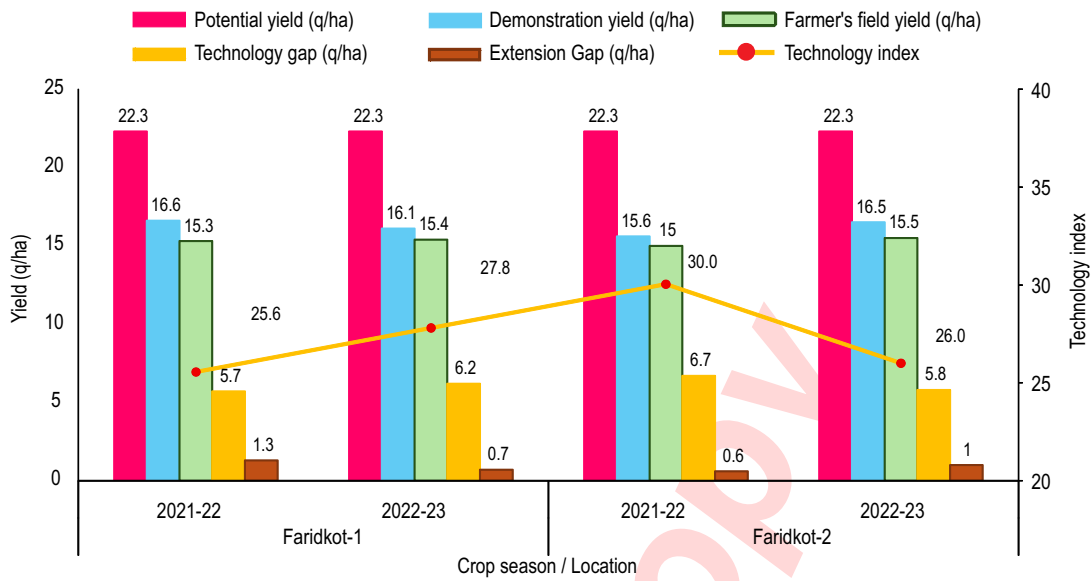


Fig. 5: Grain yield and gap analysis of CFLD on gobhi sarson.

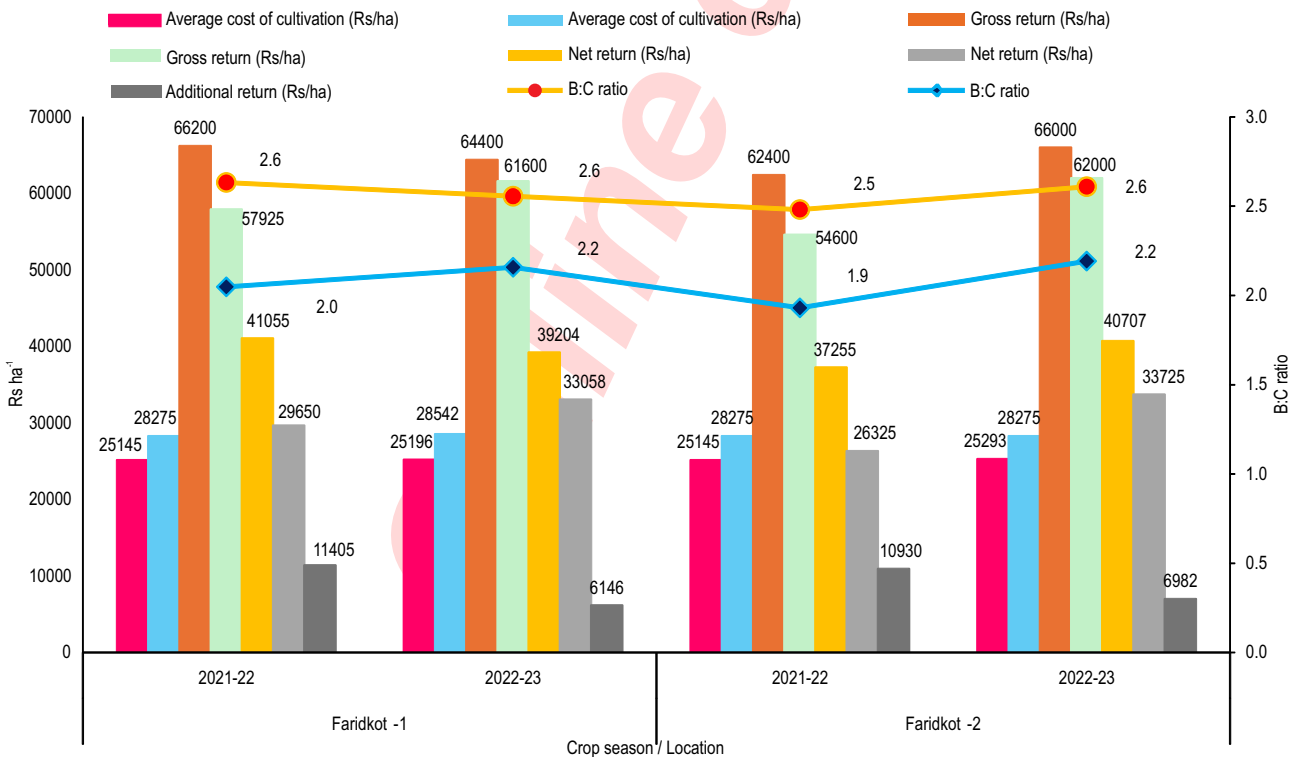


Fig. 6: Economic analysis of demonstrated and farmer's practice.

potential yield, but it found better yields than farmer's fields showing efficacy of PAU recommendations. In Uttar Pradesh, it was recorded that the mustard yield reduced by 14-18 per cent due to heat stress in 2021-22 (Bal et al., 2022). The year 2021-22

experienced high temperature, low humidity, and reduced rainfall, contributing to heat stress conditions (Anand et al., 2025). For every 1°C rise in temperature, the yield of wheat, soybean, mustard, groundnut and potato are expected to decline by 3-7%

(Agarwal, 2009). Heat stress, precisely during the reproductive and grain-filling stages, compromises yield and quality by accelerating senescence and reducing grain size (Milus et al., 2009). Elevated temperature shortened most phenophases, except physiological maturity, which was advanced by 17–18 days. The impact of temperature was most severe during siliqua formation and seed filling stages (Brar et al., 2022).

Higher demonstration yield than farmer's field was also reported by Singh et al. (2025). The results corroborates with the previous reports (Matharu and Tanwar, 2018; Patel et al., 2013; Raj et al., 2013; Poonia and Pithia, 2011). The number of siliquae on the main stem is considered a key indicator of heat stress tolerance in canola, where early heat stress reduces siliquae on the main stem and late heat stress decreases siliquae on the branches (Chen et al., 2020). Ahmad et al. (2021) also reported reductions in total siliquae per plant, seed weight and seeds per siliqua in *Brassica* species under temperature stress. Similar effects of terminal heat stress on reduced siliquae number in *Brassica* have also been documented by Sharma and Sardana (2013). The technology gap was observed higher (6.2 q ha⁻¹) during 2022-23 than 2021-22 (5.7 q ha⁻¹) in Faridkot-1 cluster. The technology gap in Faridkot-2 cluster was higher (6.7 q ha⁻¹) in first year under study as compared to second year (5.8 q ha⁻¹). Reduction in the extension gap was observed in the case of Faridkot-1, i.e., 1.3 q ha⁻¹ (2021-22) to 0.7 q ha⁻¹ (2022-23).

In Faridkot-2 cluster, the increase in extension gap was observed from 0.6 q ha⁻¹ (2021-22) to 1.0 q ha⁻¹ (2022-23). The extension gap clearly shows that Faridkot-1 farmers were closer to demonstration yield than Faridkot-2. This necessitates concentration on the extension activities to educate farmers to follow Package of Practices (Singh and Singh, 2020). Faridkot-2 cluster showed decrease in value of technology index during 2022-23 (30.0) than 2021-22 (26.0). These results are in accordance with Matharu and Tanwar (2018) and Bar and Das (2015). The higher value of technology index can be due to unfavourable weather conditions (Pawar et al., 2018).

The average cost of cultivation of frontline demonstration fields was lower (Rs 25145 to 25293) as compared to farmer's fields (Rs 28275-28542) implying less input cost in case of improved practices (Fig. 6). Demonstration fields consistently recorded higher gross and net returns than the farmer's fields in both clusters. In the Faridkot-1 cluster, during 2021-22 and 2022-23, the demonstration fields obtained gross returns of Rs 66,200 and Rs 64,400 per hectare, with corresponding net returns of Rs 41,055 and Rs 39,204 per hectare, respectively, as compared to the farmer's fields. Lower gross returns of Rs 54,600 and Rs 62,000 per hectare with corresponding net returns of Rs 26,325 and Rs 33,725 per hectare were obtained from farmer's fields during 2021-22 and 2022-23 respectively. B:C ratio was higher in case of demonstration fields as compared to farmer's fields implying that demonstration fields were more profitable as compared to farmer's fields. Additional returns were higher during 2021-22 in both Faridkot-1 (Rs 11,405 ha⁻¹) and Faridkot-2 (Rs 10,930 ha⁻¹), but it reduced during the subsequent year i.e. Rs

6,146 and Rs 6,982 per hectare at Faridkot-1 and Faridkot-2, respectively during 2022-23. Higher economic returns were obtained by using recommended package of practices under frontline demonstration over farmers' practice was also reported by Preeti and Singh (2025). Adoption of improved production techniques in oilseeds may substantially enhance the oilseed productivity and farmers' profitability (Bhatt et al., 2024).

The frontline demonstration plots surpassed farmer's field in terms of yield and economics despite extreme weather conditions indicative of importance of PAU recommendations. Seasonal variability plays an important role in influencing yield gaps. Frontline demonstrations on new technologies strengthen farmer's knowledge, confidence and willingness to adopt new recommendations.

Acknowledgments

The authors sincerely acknowledge the support and funding provided by the ICAR- Agricultural Technology Application Research Institute (ATARI), Zone-1, Ludhiana. Also, authors extend their thanks to Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana for providing weather data.

Authors' contribution: K.S. Matharu: Conducted demonstrations, Data analysis, interpretation and manuscript preparation; S. Anand: Data analysis, interpretation and manuscript preparation; P. Singh: Conducted demonstrations and Data collection.

Funding: These frontline demonstrations were conducted by funding provided by the ICAR- Agricultural Technology Application Research Institute (ATARI), Zone-1, Ludhiana.

Research content: The demonstration data of the manuscript is original and has not been published anywhere else.

Ethical approval: The authors declare that there are no ethical issues associated with this study.

Conflict of interest: The authors involved in this research declare no conflict of interest. They affirm that there are no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

Data availability: The data supporting this study's findings can be obtained from the Corresponding author upon reasonable request.

Consent to publish: All the authors agree to publish the paper in *Journal of Environment Biology*.

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