



Enhancing Productivity and Profitability of Greengram (*Vigna radiata* L.) Through Cluster Frontline Demonstrations in Inner Kashmir Himalaya

Raies A. Bhat¹, Tanveer Ahmad Ahngar², Raiz A. Lone³, Waseem Raja⁴, Zahida Rashid⁵, Asif Mohd Iqbal⁶, Aamir Hassan Mir⁷, J.S. Yadav⁸, Ajaz A. Lone⁵

10.18805/LR-5501

ABSTRACT

Background: India is the largest producer and consumer of pulses despite this, a significant gap between demand and supply persists, necessitating imports. Pulses are a rich source of protein (20-25%) and play a crucial role in nutritional security and sustainable agriculture. Among pulse crops, greengram [*Vigna radiata* (L.) Wilczek] is an important short-duration legume contributing to soil fertility and farm income. However, its productivity in Jammu and Kashmir, particularly in Kupwara district, remains significantly lower than the national average due to non-availability of improved varieties, poor crop management practices and high incidence of biotic and abiotic stresses. To address these constraints, cluster frontline demonstrations (CFLDs) were implemented under the national food security mission (NFSM) to promote improved production technologies.

Methods: The study was conducted by KVK Kupwara during *Kharif* seasons of 2021-22 and 2022-23 through 50 frontline demonstrations covering an area of 20 ha in villages including Natnussa, Deedikote, Ogbal, Jumagund and adjoining locations under rainfed conditions. The demonstrations involved improved greengram variety KM-2241 along with a full package of recommended practices, including line sowing, seed treatment with biofertilizers, integrated nutrient management and plant protection measures. Farmers' traditional practices were maintained as control for comparison.

Result: The results revealed that improved technologies significantly enhanced growth, yield attributes and productivity of greengram. The average grain yield under improved technology ranged from 10.5 to 11.5 q ha⁻¹ compared to 5.5 to 6.0 q ha⁻¹ under farmers' practices, resulting in yield enhancement of 91.00% and 91.66% during 2021-22 and 2022-23, respectively. The technology gap decreased from 1.5 to 0.5 q ha⁻¹, while the technology index reduced from 12.5% to 4.16%, indicating better adaptability of improved practices. Economic analysis showed that demonstration plots recorded higher net returns (Rs. 52,500-73,160 ha⁻¹) and benefit-cost ratio (2.01-2.41) compared to farmers' practices (Rs. 15,160-17,500 ha⁻¹ and 0.67-0.77, respectively), highlighting the economic viability of improved technologies. The study clearly demonstrates that adoption of improved greengram production technologies through CFLDs can substantially enhance productivity, profitability and farmer adoption in the Inner Kashmir Himalayan region. Scaling up of such demonstrations, strengthening extension services and ensuring timely availability of quality inputs are essential to bridge the yield gap and promote sustainable pulse production.

Key words: Cluster frontline demonstration (CFLD), Economics, Greengram, Productivity, Technology gap, Yield.

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] is one of the most important pulse crops cultivated in tropical and subtropical regions of the world, particularly in South and Southeast Asia. It belongs to the family Fabaceae (Leguminosae) and has a diploid chromosome number of $2n = 22$. The crop is predominantly self-pollinated with limited natural outcrossing (1-5%) and exhibits wide genetic variability for traits such as yield, maturity duration and resistance to biotic and abiotic stresses. Greengram is characterized by a short life cycle (60-70 days), making it highly suitable for multiple cropping systems and climate-resilient agriculture (Patel *et al.*, 2022). It is also an excellent source of plant protein (20-25%), essential amino acids, vitamins and minerals and plays a vital role in improving soil fertility through biological nitrogen fixation.

About 4.9 million hectares (49 lakh ha) area is covered under greengram cultivation in India, with an annual production of approximately 2.6 million tonnes. Over recent years, particularly between 2016 and 2017, the acreage under mungbean has increased substantially due to rising demand and government initiatives (Bhat *et al.*, 2023). Rajasthan contributes nearly 48% of the total area and 42% of production, followed by major states such as Madhya Pradesh, Maharashtra, Karnataka, Bihar, Gujarat,

¹Krishi Vigyan Kendra, Kupwara-193 222, Jammu and Kashmir, India.

²ARSS and TSS, SKUAST-K, Dussu, Pampore-192 121, Jammu and Kashmir, India.

³Division of Floriculture and Landscape Architecture, Faculty of Horticulture, SKUAST-K, Shalimar-190 025, Jammu and Kashmir, India.

⁴Division of Agronomy, FoA, SKUAST-K, Wadura-193 201, Jammu and Kashmir, India.

⁵Dry Land Agriculture Research Station, SKUAST-K, Rangreth-191 132, Jammu and Kashmir, India.

⁶ICAR-Indian Grassland and Fodder Research Institute, Regional Research Station, Rangreth, Srinagar-191 132, Jammu and Kashmir, India.

⁷Research Centre for Residue and Quality Analysis, Faculty of Horticulture, SKUAST-K, Shalimar-190 025, Jammu and Kashmir, India.

⁸School of Agricultural Sciences, K.R. Mangalam University, Gurugram-122 103, Haryana, India.

Corresponding Authors: Tanveer Ahmad Ahngar, Ajaz A. Lone; Advanced Research Station for Saffron and Temperate Seed Spices, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Dussu, Pampore-192 121, Jammu and Kashmir, India; Dry Land Agriculture Research Station, SKUAST-K, Rangreth-191 132, Jammu and Kashmir, India.

Email: tanveerahmad25@skuastkashmir.ac.in; ajazlone@skuastkashmir.ac.in

ORCID: 0000-0001-9804-9424, 0000-0002-0914-169X

How to cite this article: Bhat, R.A., Ahngar, T.A., Lone, R.A., Raja, W., Rashid, Z., Iqbal, A.M., Mir, A.H., Yadav, J.S. and Lone, A.A. (2026). Enhancing Productivity and Profitability of Greengram (*Vigna radiata* L.) Through Cluster Frontline Demonstrations in Inner Kashmir Himalaya. *Legume Research*. 49(9): 1596-1602. doi: 10.18805/LR-5501.

Submitted: 09-04-2025 **Accepted:** 25-04-2026 **Online:** 04-05-2026

Andhra Pradesh, Odisha, Tamil Nadu and Uttar Pradesh, collectively accounting for nearly 90% of national production. Pulses play a critical role in sustainable agriculture by improving soil health, enhancing biodiversity and supporting intercropping systems (Jayaramasoundari, 2024).

With increasing population pressure and a shift towards plant-based diets, pulses are emerging as a low-carbon and climate-resilient food source, contributing significantly to nutritional security. It is projected that by 2050, India will require nearly 39 million tonnes of pulses to meet domestic demand. Pulses, including greengram, are rich in protein and form an essential component of Indian diets, particularly for vegetarian populations (Garud *et al.*, 2023). They also contribute to income generation and livelihood security of small and marginal farmers (Singh *et al.*, 2026). Despite its importance, the productivity of greengram in India remains sub-optimal due to several constraints. In Jammu and Kashmir, particularly in Kupwara district, greengram cultivation is limited and yields are significantly lower than the national average. The average productivity in the Union Territory is about 247 kg ha⁻¹, whereas in Kupwara district it is only 189 kg ha⁻¹. The major constraints responsible for low productivity include non-availability of improved varieties, erratic rainfall, cultivation on marginal lands, use of low-quality seeds, poor crop establishment methods (broadcasting), lack of seed treatment with biofertilizers (*Rhizobium* and PSB), inadequate nutrient and micronutrient management and high incidence of pests and diseases, particularly yellow mosaic virus (YMV).

Cluster frontline demonstrations (CFLDs), implemented under the national food security mission (NFSM) by the Indian Council of Agricultural Research (ICAR), have emerged as an effective extension approach to bridge the yield gap by demonstrating location-specific improved technologies at farmers' fields (Kumar *et al.*, 2019) and Singh *et al.* (2022). CFLDs provide an opportunity to

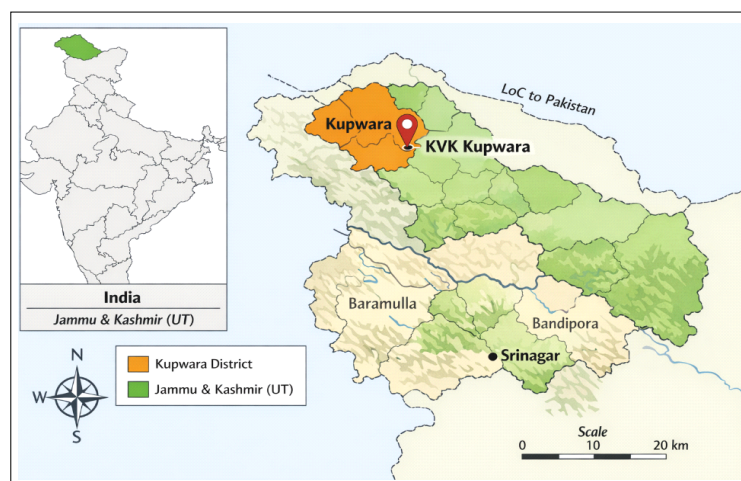
evaluate the performance of improved varieties and scientific crop management practices under real farming conditions while enhancing farmer awareness and adoption Annu *et al.* (2026) and Jakhar *et al.* (2025). In this context, Krishi Vigyan Kendra (KVK), Kupwara initiated cluster frontline demonstrations on greengram to address the prevailing production constraints through integrated technological interventions. These included the introduction of improved variety KM-2241, which is early maturing, high yielding and moderately resistant to yellow mosaic virus, along with improved agronomic practices such as line sowing, seed treatment, balanced nutrient management and integrated pest management.

However, limited systematic studies are available on the impact of CFLDs on greengram productivity and profitability under the specific agro-ecological conditions of the Inner Kashmir Himalayan region. Therefore, the present study was undertaken to evaluate the performance of improved production technologies demonstrated through CFLDs in comparison with farmers' traditional practices and to quantify yield gaps, technology gaps and economic benefits under real farm conditions in Kupwara district of Jammu and Kashmir.

MATERIALS AND METHODS

Study area and experimental site

The present investigation was conducted under the Cluster Frontline Demonstration (CFLD) programme by Krishi Vigyan Kendra (KVK), Kupwara, during the *Kharif* seasons of 2021-22 and 2022-23 in Kupwara district of Jammu and Kashmir, India. The study area falls under the Inner Kashmir Himalayan agro-ecological region, characterized by temperate climatic conditions, moderate rainfall and undulating topography. The demonstrations were carried out under rainfed conditions in selected villages, namely Natnussa, Deedikote, Ogbal and Jumagund, representing major greengram-growing pockets of the district (Map 1).



Map 1: Study area of Kupwara district.

The region receives an average annual rainfall of approximately 700-900 mm, mostly concentrated during the monsoon period (June-September), with mean temperature ranging between 18-30°C during the cropping season. Such climatic variability significantly influences crop performance and yield stability in greengram cultivation.

Soil characteristics

The soils of the experimental sites were predominantly clay loam in texture with medium fertility status. Soil analysis indicated slightly acidic to neutral reaction (pH 6.5-7.2), medium organic carbon content (0.50-0.65%), available nitrogen (280-320 kg ha⁻¹), phosphorus (18-22 kg ha⁻¹) and potassium (160-190 kg ha⁻¹). Micronutrient deficiency, particularly zinc, was observed in some locations, necessitating its application under improved technology treatments.

Selection of farmers and demonstration layout

Frontline demonstrations were conducted on farmers' fields following a cluster approach, wherein contiguous farmers were selected to enhance visibility and adoption of improved technologies. A total of 50 demonstrations covering 20 ha area were conducted over two years, involving 30 farmers in 2021-22 and 40 farmers in 2022-23. Each demonstration was laid out on 0.4 ha area and an adjacent 0.4 ha plot under farmers' traditional practices was maintained as a control (local check) for comparison. Uniformity between demonstration and farmers' plots was ensured by selecting fields with similar soil type, topography and cropping history. Details of green gram grown under FLD and farmer's practice tabulated in Table 1.

Experimental design and treatments

The study followed a paired plot comparison approach under real farming conditions, which is commonly adopted in CFLD programmes. The treatments consisted of:

- **Improved technology (IT):** Demonstration plots with commended package of practices.
 - **Farmers' practice (FP):** Local cultivation practices followed by farmers.
- The improved technology package included:
- Use of high-yielding greengram variety KM-2241 (released in 2009).
 - Line sowing (30 cm × 10 cm spacing) instead of broadcasting.
 - Seed treatment with systemic insecticide followed by biofertilizers (Rhizobium and PSB @ 500 g ha⁻¹).
 - Integrated nutrient management (FYM @ 3 t ha⁻¹ + RDF @ 25:50:25 kg NPK ha⁻¹ + ZnSO₄ @ 10 kg ha⁻¹ + foliar spray of 2% DAP at pre-flowering stage).
 - Weed management using Pendimethalin @ 1 kg ha⁻¹ as pre-emergence followed by intercultivation at 35-40 DAS.
 - Need-based plant protection measures.

Crop establishment and management practices

Sowing of greengram was carried out during the last week of June in 2021-22 and first week of July in 2022-23, depending on monsoon onset. The crop was sown in rows with a spacing of 30 cm between rows and 10 cm between plants. Weeding and thinning operations were performed at 10-15 DAS and 35-40 DAS to maintain optimum plant population. Other agronomic practices such as irrigation (wherever supplemental irrigation was possible), pest and disease management and harvesting were carried out as per recommended package of practices.

Table 1: Particulars showing the details of green gram grown under FLD and farmer's practice.

Particulars	Farmers practice	Technology intervention	Gap
Variety	Local	KM-2241	Full gap
Seed rate	30 kg/ha	8 kg/ha	Partial gap
Sowing	Broadcasting	Line sowing	Partial gap
Seed treatment	No treatment	Seed treatment with systemic insecticide fb by rhizobium and PSB @ 500 g/ha, respectively.	Full gap
Nutrient management	Only FYM applied and no fertilizers	Application of FYM 3 t/ha, RDF @ 25:50:25 NPK kg/ha, ZnSO ₄ @ 10 kg/ha, Foliar application DAP @ 2% during pre-flowering.	Partial gap
Weed management	Hand weeding or no weed management	Weeds control by using herbicide pendimethalin 1 kg/ha in 500 liter of water as pre-emergence treatment for effective control of weeds within two days after sowing. + one inter-cultivation @ 35-40 DAS.	Partial gap
Plant protection	No application of plant protection chemicals	Need based plant protection chemicals were used.	Full gap

Note: IT- Improved technologies, FP- Farmers practice.

Data collection and observations

Data on growth and yield attributes were recorded from randomly selected plants in each plot, including: plant height (cm), number of branches per plant, number of pods per plant, number of seeds per pod and 100-seed weight (g). Grain yield was recorded from each plot and expressed in q ha⁻¹. Economic parameters such as cost of cultivation, gross returns, net returns and benefit-cost (B:C) ratio were calculated based on prevailing market prices.

Yield gap analysis and indices

The performance of demonstrated technologies was evaluated using standard indices such as technology gap, extension gap and technology index, following established procedures (Meena and Singh, 2017). The potential yield (12 q ha⁻¹) was considered based on varietal performance reported under research station conditions of SKUAST-Kashmir.

The parameters were calculated using the following formulae:

Extension gap (EG) =

Demonstration yield (DY) - Farmers' practice yield (FPY)

Technology gap (TG) =

Potential yield (PY) - Demonstration yield (DY)

$$\text{Technology index (TI)} = \frac{\text{PY} - \text{DY}}{\text{PY}} \times 100$$

Where,

DY = Demonstration yield (q ha⁻¹).

FPY = Farmers' practice yield (q ha⁻¹).

PY = Potential yield (q ha⁻¹).

Statistical analysis

Descriptive statistical analysis was employed to compare the performance of improved technologies and farmers' practices. Mean values, percentage increase over farmers' practices and economic indicators were calculated.

Although CFLD studies are primarily extension-oriented, basic comparative analysis was performed to ensure reliability and consistency of results.

RESULTS AND DISCUSSION

Growth, yield attributes and yield

The results of the present study clearly indicated that greengram growers in Kupwara district responded positively to the cluster frontline demonstrations (CFLDs), which facilitated the adoption of improved production technologies. The demonstration plots (Improved Technologies, IT) recorded superior performance in all growth and yield-attributing traits, including plant height, number of branches per plant, number of pods per plant, number of seeds per pod and 100-seed weight, as compared to farmers' practice (FP) and it's with Mean $\pm$ SD (Table 2).

For instance, the average plant height under improved technology was 32.5 cm compared to 24 cm under farmers' practice, while the number of pods per plant increased from 11.15 (FP) to 25.0 (IT), indicating a substantial improvement in crop growth and reproductive potential. Similarly, the 100-seed weight under improved technology was approximately 5.95 g (corrected average) compared to 3.5 g under farmers' practice, reflecting better grain filling and seed development.

This improvement in growth and yield attributes can be attributed to the combined effect of improved variety (KM-2241), balanced nutrient management, proper plant spacing through line sowing, seed treatment with biofertilizers and effective pest and disease management, which enhanced resource-use efficiency and crop vigor. The enhanced performance of KM-2241 may also be associated with its genetic potential for higher yield and moderate resistance to yellow mosaic virus (YMV), which is a major constraint in the region. These findings are in agreement with earlier reports by Singh and Singh (2021)

Table 2: Growth and yield attributing characters of green gram variety KM-2241 in comparison with farmers practice.

Parameter	Year	IT (Mean $\pm$ SD)	FP (Mean $\pm$ SD)
Plant height (cm)	2021-22	33.0 $\pm$ 1.2	23.0 $\pm$ 1.0
	2022-23	32.0 $\pm$ 1.1	25.0 $\pm$ 1.3
	Pooled	32.5 $\pm$ 1.15	24.0 $\pm$ 1.15
Branches/plant	2021-22	4.5 $\pm$ 0.2	3.0 $\pm$ 0.2
	2022-23	4.6 $\pm$ 0.3	3.2 $\pm$ 0.3
	Pooled	4.55 $\pm$ 0.25	3.10 $\pm$ 0.25
Pods/plant	2021-22	24.0 $\pm$ 2.0	10.0 $\pm$ 1.5
	2022-23	26.5 $\pm$ 2.3	12.3 $\pm$ 1.8
	Pooled	25.25 $\pm$ 2.15	11.15 $\pm$ 1.65
Seeds/pod	2021-22	13.3 $\pm$ 0.8	9.8 $\pm$ 0.7
	2022-23	14.6 $\pm$ 0.9	10.4 $\pm$ 0.8
	Pooled	13.95 $\pm$ 0.85	10.10 $\pm$ 0.75
100-seed weight (g)	2021-22	5.60 $\pm$ 0.3	3.40 $\pm$ 0.2
	2022-23	6.30 $\pm$ 0.4	3.60 $\pm$ 0.3
	Pooled	5.95 $\pm$ 0.35	3.50 $\pm$ 0.25

and Amuthaselvi *et al.* (2023), who observed significant improvement in growth and yield attributes under improved production technologies in greengram.

Grain yield of greengram varied across years, which may be attributed to inter-annual variability in rainfall distribution, soil moisture availability and pest/disease incidence under rainfed conditions. Similar variability in greengram yield has been reported by Kumar and Boparai (2020). However, despite such variability, demonstration plots consistently outperformed farmers' practices in both years (Table 3). The average grain yield under improved technology ranged from 10.5 to 11.5 q ha⁻¹ compared to 5.5 to 6.0 q ha⁻¹ under farmers' practice, resulting in yield enhancement of 91.00% and 91.66% during 2021-22 and 2022-23, respectively (increment per cent and yield gap in Table 3a). This substantial yield increase clearly demonstrates the effectiveness of CFLDs in bridging the yield gap through adoption of improved technologies. Similar yield improvements under frontline demonstrations have been reported by Singh and Singh (2021) and Chandra (2010).

Technology gap

The technology gap, which represents the difference between potential yield and demonstration yield, was observed to be 1.5 q ha⁻¹ during 2021-22 and 0.5 q ha⁻¹ during 2022-23 (Table 4). The reduction in technology gap in the second year indicates better adaptation and adoption of improved technologies by farmers, as well as relatively favourable climatic conditions. However, the existence of a technology

gap suggests that further refinement of location-specific management practices is required to fully exploit the yield potential of greengram. The observed technology gap may be attributed to variability in soil fertility status, uneven rainfall distribution and differences in management practices across locations, as also reported by Amuthaselvi *et al.* (2023) and Borah *et al.* (2026). Therefore, site-specific nutrient and crop management strategies are essential to minimize this gap and enhance productivity under rainfed conditions.

Extension gap

The extension gap, which indicates the difference between demonstration yield and farmers' yield, was recorded as 5.0 q ha⁻¹ and 5.0 q ha⁻¹ during 2021-22 and 2022-23, respectively (Table 4). This substantial extension gap highlights the wide disparity between improved technologies and traditional farming practices, emphasizing the need for effective dissemination of scientific crop production technologies among farmers. The results clearly indicate that large-scale adoption of improved varieties, scientific nutrient management and plant protection measures can significantly enhance greengram productivity in the region. Similar extension gaps in pulse crops have been reported by Singh *et al.* (2026); Kumar and Boparai (2020) and Bhat *et al.* (2023), who emphasized the importance of strengthening extension services to improve technology adoption.

Technology index

The technology index, which reflects the feasibility and adoption of improved technologies, was found to be 12.5%

Table 3: Seed yield of greengram as affected by improved and farmers practices in farmers' fields.

Year	Area (ha)	No. of farmers	Seed yield (q/ha)		Additional yield over farmers practice (kg/ha)	% increase over check
			IT	FP		
2021-22	10	30	10.50	5.5	5.00	91.00
2022-23	10	40	11.50	6.0	5.5	91.66
Mean			11.0	5.75	5.25	91.33

Note: IT- Improved technologies, FP- Farmers practice.

Table 3a: Seed yield increase (%) and yield gap of greengram.

Year	IT yield (q/ha)	FP yield (q/ha)	Yield increase (%)	Yield gap (q/ha)
2021-22	10.5±0.6	5.5±0.5	91.00	5.0
2022-23	11.5±0.7	6.0±0.5	91.66	5.5
Mean	11.0±0.65	5.75±0.50	91.33	5.25

Table 4: Technological gap analysis of frontline demonstrations on greengram in farmer's field.

Year	Area (ha)	Seed yield (q/ha)			Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
		Potential	Demonstration	Farmers practice			
2021-22	10	12.0	10.50	5.5	1.50	5.0	12.5
2022-23	10	12.0	11.0	6.0	0.50	5.0	8.33
Mean		12.0	10.75	5.75	1.25	5.0	10.41

Table 5: Economics of frontline demonstrations on greengram in farmer's field.

Year	Cost of cultivation (Rs./ha)		Gross return (Rs./ha)		Net return (Rs./ha)		B: C ratio	
	IT	FP	IT	FP	IT	FP	IT	FP
2021-22	31350	22340	94500	37500	52500	15160	2.01	0.67
2022-23	30340	22500	103500	40000	73160	17500	2.41	0.77

Note: IT- Improved technologies, FP- Farmers practice.

during 2021-22 and 4.16% during 2022-23 (Table 4). A decreasing trend in technology index indicates improved performance and higher acceptability of demonstrated technologies under farmers' conditions. The lower value in the second year suggests better adaptability of the technology package and favourable environmental conditions. These values are considerably lower than those reported by Kumar *et al.* (2019) and Kumar *et al.* (2023), who observed technology index values ranging from 55.00 to 70.85%, indicating the higher feasibility and effectiveness of the demonstrated technologies in the present study. However, limited access to quality inputs, variability in soil fertility and sub-optimal crop management practices continue to constrain the realization of full yield potential in Kupwara district. Therefore, integrated approaches involving improved seed availability, balanced fertilization and efficient water and pest management are essential for sustainable intensification of greengram production.

Economics

The economic analysis of greengram cultivation under Cluster Frontline Demonstrations (CFLDs) clearly indicated the superiority of improved technologies over farmers' traditional practices (Table 5). Although the cost of cultivation was relatively higher in demonstration plots due to the use of improved inputs such as quality seed, fertilizers, micronutrients and plant protection measures, the overall economic returns were substantially enhanced. During 2021-22, the demonstration plots recorded a gross return of Rs. 94,500 ha⁻¹ and net return of Rs. 52,500 ha⁻¹ with a benefit-cost (B:C) ratio of 2.01, compared to Rs. 37,500 ha⁻¹ gross return, Rs. 15,160 ha⁻¹ net return and B:C ratio of 0.67 under farmers' practices. Similarly, in 2022-23, the improved technology plots recorded a gross return of Rs. 1,03,500 ha⁻¹ and net return of Rs. 73,160 ha⁻¹ with a B:C ratio of 2.41, whereas farmers' practices resulted in Rs. 40,000 ha⁻¹ gross return, Rs. 17,500 ha⁻¹ net return and B:C ratio of 0.77. The higher economic returns under improved technology can be attributed to significantly higher grain yield, better input-use efficiency and improved crop management practices. The increase in net returns ranged from approximately 246% to 318% over farmers' practices, indicating strong economic viability of CFLD interventions.

The improved variety KM-2241, combined with scientific crop management practices such as line sowing, seed treatment with biofertilizers, balanced nutrient application and integrated pest management, contributed to enhanced productivity and profitability. The moderate resistance of KM-2241 to yellow mosaic virus (YMV) and

tolerance to pod borer further reduced yield losses and improved economic returns under field conditions. These findings are in close agreement with earlier studies by Singh *et al.* (2017) and Natarajan *et al.* (2024) who reported significant improvement in profitability under frontline demonstrations in mungbean. Similarly, Kumar and Boparai (2020) observed B:C ratios ranging from 1.92 to 2.44 under improved technologies, which are comparable with the present findings. Meena and Singh (2017) also reported higher net income (Rs. 46,030 ha⁻¹) and B:C ratio (4.3) under improved practices compared to farmers' methods. Kumar *et al.* (2019) further reported B:C ratios ranging from 3.20 to 6.56 in greengram under improved varieties. The results clearly demonstrate that adoption of improved greengram production technologies under CFLDs not only enhances yield but also significantly improves farm income and livelihood security. The widespread adoption of such technologies can play a crucial role in horizontal expansion (increase in area) and vertical expansion (increase in productivity) of greengram cultivation in Kupwara district and similar agro-ecological regions.

CONCLUSION

The results of the present study clearly demonstrate that cluster frontline demonstrations (CFLDs) significantly enhanced the productivity and profitability of greengram cultivation in Kupwara district through the adoption of improved technologies. The introduction of the improved variety KM-2241, along with recommended scientific crop management practices, resulted in substantial improvement in yield, economic returns and overall farm efficiency compared to farmers' traditional practices. The higher net returns and benefit-cost ratio observed under improved technology indicate its strong economic viability and potential for improving livelihood security of small and marginal farmers. The CFLDs also played a crucial role in enhancing farmers' awareness, skill development and adoption of improved agricultural practices, thereby facilitating the horizontal spread of the technology in the region. Although the presence of a considerable extension gap highlights the need for strengthening extension services and wider dissemination of improved technologies, the relatively lower technology gap and technology index indicate good adaptability and feasibility of the demonstrated package under farmers' field conditions. Therefore, scaling up of CFLDs, strengthening input delivery systems and promoting location-specific agronomic practices are essential to bridge the existing yield gap and ensure sustainable greengram

production in the Inner Kashmir Himalayan region. Future research should focus on refinement of crop management practices under rainfed conditions, integration of climate-resilient technologies and evaluation of improved varieties across diverse agro-ecological niches to further enhance productivity and stability.

ACKNOWLEDGEMENT

ICAR, ATARI, Zone-1 Ludhiana, Directorate of Extension SKUAST-Kashmir and DARS, SKUAST-Kashmir, provided support for this work.

Disclaimers

The opinions and findings presented in this article are those of the authors alone and may not be representative of those of the organizations with which they are affiliated. Although the writers are in charge of the information's correctness and comprehensiveness, they disclaim all obligation for any losses, whether direct or indirect, that may arise from using this content.

Conflict of interest

According to the authors, they have no conflicts of interest with regard to the publication of this work. No sponsorship or funding had an impact on the study's design, data collection, analysis, publication decision, or manuscript preparation.

REFERENCES

- Amuthaselvi, G., Anand, G., Vijayalakshmi, R., Kanif, N.A., Dhanushkodi, V., Gayathri, M. and Ravi, M. (2023). Yield gap analysis through cluster front line demonstration in blackgram at Tiruchirappalli district. *Legume Research*. **46(7)**: 898-901. doi: 10.18805/LR-5119.
- Annu, M. S.S., Singh, S.S., Parkash, O. and Kumar, A. (2026). Cluster frontline demonstration: An effective technology dissemination approach for enhancing productivity and profitability of summer mung (*Vigna radiata* L.). *Legume Research*. **49(4)**: 619-623. doi: 10.18805/LR-5361.
- Bhat, R.A., Malik, K.M., Din, S.M., Hakeem, S.A., Raina, F.A., Bhat, F.N. and Nissar, R. (2023). Pulse productivity and profitability as influenced by cluster frontline demonstrations in Kupwara district of Jammu and Kashmir, India. *International Journal of Environment and Climate Change*. **13(11)**: 905-912.
- Borah, J., Das, P., Deka, P., Deka, K., Deka, D., Chutia, R. and Sarma, U.J. (2026). A comprehensive evaluation of cluster frontline demonstration (CFLD) on field pea (*Pisum sativum* L.) in Baksa District, Assam. *Legume Research*. **49(6)**: 1015-1021. doi: 10.18805/LR-5519.
- Chandra, G. (2010). Evaluation of frontline demonstration on greengram (*Vigna radiata* L.) in sundarbans, West Bengal. *Journal of the Indian Society of Coastal Agricultural Research*. **28(1)**: 12-15.
- Garud, H.S., Gaikwad, B.B., Surpam, T.B., Patgaonkar, D.C. and Jagtap, K.L. (2023). Impact of cluster front line demonstrations on productivity and profitability of pigeonpea under NFSM in beed District of Maharashtra, India. *Legume Research*. **46(7)**: 888-892. doi: 10.18805/LR-5116.
- Jakhar, S.R., Tripathy, S., Sharma, B., Kantwa, C.R., Ghaswa, R., Bhadauria, R.S., Kumar, S. and Tiwari, G.P. (2025). Cluster frontline demonstration: An effective technology dissemination approach for maximization of productivity and profitability of chickpea (*Cicer arietinum* L.). *Legume Research*. **48(3)**: 480-484. doi: 10.18805/LR-5304.
- Jayaramasoundari, R. (2024). Enhancing productivity and profitability of black gram (*Vigna mungo*) through cluster front line demonstrations. *Indian Journal of Agricultural Research*. **58(5)**: 806-810. doi: 10.18805/IJAR.A-6205.
- Kumar, P. and Boparai, A.K. (2020). Impact of summer mung through improved technology in Jalandhar district of Punjab, India. *International Journal of Current Microbiology and Applied Sciences*. **9(5)**: 3495-3501.
- Kumar, S., Mahajan, V., Sharma, P.K. and Parkash, S. (2019). Impact of front-line demonstrations on the production and productivity of moong (*Vigna radiata* L.), mash (*Vigna mungo* L.), rajmash (*Phaseolus vulgaris* L.), lentil (*Lens culinaris* L.) and chickpea (*Cicer arietinum* L.) under rainfed ecology in mid hills of J and K, India. *Legume Research*. **42(1)**: 127-133. doi: 10.18805/LR-3816.
- Kumar, U., Patel, G.A., Chudhari, R.P., Darji, S.S. and Raghav, R.S. (2023). Cluster frontline demonstration: An effective technology dissemination approach for enhancing productivity and profitability of black gram (*Vigna mungo*). *Legume Research: An International Journal*. **46(10)**: 1356-1360. doi: 10.18805/LR-4450.
- Meena, M.L. and Singh, D. (2017). Technological and extension yield gaps in greengram in Pali district of Rajasthan, India. *Legume Research*. **40(1)**: 187-190. doi: 10.18805/LR-01OF.3549.
- Natarajan, K., Noorjehan A.K.A. Hanif, Jayakumar, J., Senguttuvan, K., Gayathry, G., Bharathi Kumar, K., Veeramani, P., Kannan, S. and Mailappa, A.S. (2024). A study on yield and value sustainability in groundnut (*Arachis hypogea*) through cluster frontline demonstrations approach in cuddalore District of Tamil Nadu. *Legume Research*. **47(7)**: 1172-1178. doi: 10.18805/LR-5292.
- Patel, N., Verma, N., Sahare, K.V., Sharma, A. and Sharma, S.R. (2022). Impact of CFLD on production and productivity of summer moong. *Internat. J. Agric. Sci.* **18(1)**: 69-72.
- Singh, D., Singh, K.B., Gill, N.S. and Garewal, I.S. (2017). Impact analysis of frontline demonstrations on pulses in Punjab. *International Journal of Farm Sciences*. **7(1)**: 190-194.
- Singh, J. and Singh, K. (2021). Impact assessment of front-line demonstrations on summer mung productivity under irrigated agro-ecosystem of Haryana. *Legume Research: An International Journal*. **44(12)**: 1470-1474. doi: 10.18805/LR-4517.
- Singh, O., Singh, D.K., Singh, A., Singh, R.P., Pandey, S. and Bajpai, A.K. (2022). Increasing productivity of lentil (*Lens culinaris*) using improved varieties under alluvial soil of Uttar Pradesh by cluster front line demonstrations. *Legume Research*. **45(4)**: 492-496. doi: 10.18805/LR-4704.
- Singh, P., Kumari, N., Mandal, B.S., Kaushik, P. and Nimbrayan, P.K. (2026). Impact assessment of cluster frontline demonstrations on summer moong (*Vigna radiata*) production in Sonipat, Haryana. *Legume Research*. **49(3)**: 476-481. doi: 10.18805/LR-5505.