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Bridging the yield gap in blackgram through cluster frontline demonstrations in SPSR Nellore district of Andhra Pradesh

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Abstract
Blackgram is cultivated over an area of 16,566 hectares during the rabi season in the SPSR Nellore district of Andhra Pradesh. However, productivity remains low, averaging only 696 kg ha^{-1}, primarily due to the adoption of sub-optimal cultivation practices. To address this issue and enhance productivity, Cluster Frontline Demonstrations (CFLDs) were implemented by Krishi Vigyan Kendra (KVK), Nellore across four mandals in SPSR Nellore district during the period 2020-21 to 2023-24. The demonstrations were conducted on Blackgram variety TBG-104, covering an area of 100 hectares and involving 250 farmers. The objective was to assess the impact of improved technologies on seed yield, technological gap, extension gap, technology index, and economic returns. The demonstration plots recorded seed yields of 953, 1000, 1103 and 501 kg ha^{-1} during 2020-21, 2021-22, 2022-23 and 2023-24, respectively, compared to 752, 760, 900, and 411 kg ha^{-1} under farmers' practice. The corresponding yield advantages were 25.1%, 33.4%, 22.6% and 17.9%. The four-year average analysis revealed a technological gap of 1111 kg ha^{-1}, an extension gap of 184 kg ha^{-1} and a technology index of 55.5%, reflecting the scope for further improvement. The average net return and benefit–cost ratio under demonstration plots were ₹22,750 ha^{-1} and 1.62, respectively, as against ₹10,144 ha^{-1} and 1.29 under farmers' practice. The results clearly demonstrate that adoption of improved technologies under CFLDs significantly enhanced productivity and profitability in Blackgram cultivation, thereby bridging the yield gap and benefiting the farming community of the region.

Keywords: Blackgram, cluster frontline demonstration, TBG-104, extension gap, technology index

Introduction

Blackgram (Vigna mungo), commonly known as urad in India, plays a vital role in ensuring food and nutritional security while enhancing soil fertility through its nitrogen-fixing ability. It is a staple in the Indian diet due to its high protein content of approximately 26%, which is significantly higher than that of most cereals (Reddy, 2010) [14]. India is the largest producer and consumer of blackgram globally, with major cultivation in states like Andhra Pradesh. In Andhra Pradesh alone, blackgram is grown on nearly 3.93 lakh hectares, producing about 3.65 lakh tonnes annually (Department of Agriculture and Cooperation, 2022). In SPSR Nellore district, blackgram is a key rabi pulse crop, cultivated over an area of 16,566 hectares. However, the average productivity in the district is only 696 kg ha^{-1} (Anonymous, 2018) [2], which is significantly lower than the state average of 929 kg ha^{-1} (des.ap.gov.in). The low productivity is primarily attributed to the lack of improved varieties and the poor adoption of recommended cultivation practices. Additional constraints include inefficient input management, susceptibility to biotic stresses, erratic rainfall, and poor soil fertility (Ali & Gupta, 2012) [1]. These issues are more pronounced in rainfed areas, where resource-poor farmers often lack the capacity and risk tolerance to adopt improved practices. Nonetheless, research has shown that the systematic adoption of improved agronomic practices, including the use of high-yielding varieties, can substantially increase blackgram productivity (Rai *et al*., 2015) [13]. Addressing these yield-limiting factors through targeted technological interventions is essential for enhancing production. In this context, Krishi Vigyan Kendra (KVK) serves as a vital link between research institutions and the farming community. Acting as a science-based extension agency, KVK plays a crucial role in facilitating the dissemination of location-specific technologies. The Cluster Frontline Demonstration (CFLD) approach is a proven method for transferring the latest agricultural innovations to farmers, as emphasized by Sumathi (2012) [19]. These demonstrations are strategically designed and implemented through activities such as field days, group meetings and farmer interactions to ensure effective knowledge transfer. The present study conducted by KVK, SPSR Nellore, aimed to improve blackgram productivity by showcasing advanced technological interventions through CFLDs. The demonstrations focused on bridging the existing yield gaps by introducing improved varieties and promoting the adoption of recommended package of practices among farmers.

Materials and Methods

The study was conducted across four mandals (Podalakur, Marripadu, Kaligiri and Kondapuram) of SPSR Nellore district, Andhra Pradesh, during the rabi seasons from 2020-21 to 2023-24. The blackgram variety TBG-104 was selected for the demonstrations due to its resistance to yellow mosaic virus, adaptability to all seasons and a yield potential of 20-22.5 q ha^{-1} with a crop duration of 70-75 days. Prior to the implementation of Cluster Frontline Demonstrations (CFLDs), capacity-building programmes were organized to train farmers on scientific cultivation practices. A comprehensive package of improved technologies including the recommended seed rate, improved variety, seed treatment with biofertilizers, balanced nutrient management, effective weed control and integrated plant protection measures was demonstrated on farmer's fields. In each selected village, method demonstrations on seed treatment using biofertilizers were also conducted to enhance awareness and adoption of these low-cost interventions among farmers. The scientific interventions under CFLDs (Table 1) were carried out in accordance with the recommendations of Acharya N.G. Ranga Agricultural University (ANGRAU), Guntur. A total of 250 frontline demonstrations were conducted over four years under rainfed conditions on sandy clay loam soils, characterized by low to medium fertility status. Each demonstration was laid out in an area of 0.4 ha, adjacent to the farmer's practice plots for effective comparison. The yield gain achieved under demonstration plots over farmer's practices was calculated following the method proposed by Yadav *et al*. (2004) [20]. Furthermore, Extension Gap, Technology Gap, and Technology Index were calculated using the formulas given by Samui *et al*. (2000) [16] as follows:

Technology gap = Potential yield - Demonstration yield
Extension gap = Demonstration yield - Farmers' yield

$$\text{Technology index (\%)} = \frac{\textit{Technology gap}}{\textit{Potential yield}} \times 100$$

The fields were regularly monitored and periodically observed by the scientists of the Krishi Vigyan Kendra (KVK). At the time of harvest, yield data were collected from both the demonstration plots and the farmer's practice plots. Information on the cost of cultivation and returns from both systems was obtained from the participating farmers to calculate the benefit-cost ratio. Economic parameters were worked out based on the prevailing market prices of inputs and the minimum support prices (MSP) of outputs, as per the methodology followed by Deva *et al*. (2019) [5].

Table 1: Technological Gap in CFLD and Farmers Practice of Blackgram

Particulars	Technological interventions	Existing practices	Technological gap
Land preparation	Ploughing with MB plough and cultivator	Ploughing with MB plough and cultivator	No gap
Variety	TBG-104 (Resistant to YMV)	LBG-752 (Susceptible to YMV)	Full gap
Seed rate	25 kg ha^{-1}	30 kg ha^{-1}	Partial gap
Time of sowing	Last week of september	Last week of september	No gap
Seed treatment	Rhizobium @ 10 ml kg^{-1} + Carbendazim 50% WP @ 2.5 g/kg	No seed treatment	Full gap
Biofertilizers	PSB @ 1250 ml ha^{-1} KRB @ 1250 ml ha^{-1}	No usage of biofertilizers	Full gap
Method of sowing	Line sowing	Broadcasting	Full gap
Fertilizer dose	20:40 N: P_2O_5 (Based on soil test values)	Improper use (Excess application of Nitrogenous fertilizers)	Partial gap
Weed management	Pre-emergence application of pendimethalin *fb* Post emergence application of Sodium aciflourfen + Clodinafop propargyl	Post emergence application of Propaquizafop + Imazethapyr	Partial gap
Plant protection	Arrangement of sticky traps @ 10 ha^{-1} and pheromone traps to monitor white flies and borer incidence + Need based pesticide and fungicide application	No monitoring of pests and Injudicious use of insecticides and fungicides	Partial gap
Irrigation	Rainfed	Rainfed	No gap

Results and Discussion

The results from the Cluster Frontline Demonstrations (CFLDs) conducted between 2020-21 and 2023-24 reveal substantial benefits of adopting Blackgram variety TBG-104 over traditional farmer practices (Table 2). TBG-104 along with improved agricultural practices demonstrated an average yield increase of 24.8% (183 kg ha^{-1}) compared to LBG-752. Moreover, TBG-104 exhibited resilience against Yellow Mosaic Virus, highlighting its robust performance under diverse agro-climatic conditions. However, a notably lower yield was recorded during the 2023-24 season, primarily due to low rainfall conditions and prolonged dry spells, which adversely affected crop growth and productivity. Despite this seasonal setback, the overall trend across four years affirms the positive impact of advanced agricultural technologies introduced through CFLDs. Similar patterns of yield improvement through frontline demonstrations have been reported in earlier studies by Saikia *et al*. (2018) [15] and Meena and Singh (2017) [8]. Overall, the results emphasize that CFLDs effectively promote the adoption of improved agricultural practices, enhance productivity, and mitigate disease risks thereby contributing significantly to better economic outcomes and food security in the region.

Table 2: Impact of Technological Intervention on Yield of Blackgram and Gap Analysis

Variety	Season/Year	Area (ha)	Yield (kg/ha)			Increase over farmer's practice (%)	Technology gap (kg ha^{-1})	Extension gap (kg ha^{-1})	Technology index (%)
			PY*	CFLD*	FP*				
TBG-104	Rabi (2020-21)	20	2000	953	762	25.1	1047	191	52.3
TBG-104	Rabi (2021-22)	20	2000	1000	750	33.4	1000	250	50.0
TBG-104	Rabi (2022-23)	20	2000	1103	900	22.6	897	203	44.8
TBG-104	Rabi (2023-24)	40	2000	501	411	17.9	1499	90	74.9
Average		25	2000	889	706	25.9	1111	184	55.5

PY* - Potential Yield, CFLD* - Cluster frontline demonstration and FP* - Farmer's Practice

Table 3: Economic analysis of CFLD's of Blackgram in Nellore district of Andhra Pradesh

Year	Cost of Cultivation (Rs. ha^{-1})		Grosss Returns (Rs. ha^{-1})		Net Returns (Rs. ha^{-1})		B:C Ratio	
	CFLD*	FP*	CFLD*	FP*	CFLD*	FP*	CFLD*	FP*
2020-21	39600	40828	60039	48006	20439	7178	1.52	1.18
2021-22	34500	35600	62400	47600	27900	12000	1.81	1.34
2022-23	32240	33173	66218	53996	33978	20823	2.05	1.63
2023-24	38897	38426	47580	39000	8683	574	1.11	1.02
Average	36309	37007	59059	47151	22750	10144	1.62	1.29

CFLD* - Cluster Frontline Demonstration and FP* - Farmer's Practice

Technology Gap

The technology gap refers to the difference between the potential yield attainable under optimal conditions and the actual yield realized in demonstration fields. In the present study, a technology gap of 1111 kg ha^{-1} highlights a significant scope for yield enhancement through the adoption of improved technologies. This gap can be attributed to factors such as soil fertility variation, climatic fluctuations and management practices (Mukherjee, 2003) [11]. Bridging this gap necessitates the formulation of location-specific and variety-specific agronomic recommendations, as emphasized by Rachhoya *et al*. (2018) [12], to better align technological interventions with local agro-ecological conditions.

Extension Gap

The study reveals a substantial extension gap of 184 kg ha^{-1} in yield between demonstration plots and farmers' fields, indicating a notable disparity in technology adoption. This emphasizes the critical need for targeted extension and capacity-building initiatives to bridge this gap. Promoting the adoption of high-yielding varieties and modern agronomic practices, as demonstrated in the trials, can significantly enhance productivity. Facilitating this technological shift among farmers is essential for minimizing the extension gap and fostering sustainable, profitable agricultural practices in the long term.

Technology Index

The technology index serves as a critical indicator for evaluating the adoption and effectiveness of agricultural technologies. It is computed as the ratio of the technology gap to the potential yield, expressed as a percentage. A lower technology index reflects higher effectiveness of the technological intervention (Mishra *et al*., 2007) [10]. In the present study, the technology index ranged from 44.8% to 74.9%, with an average of 55.5%, indicating considerable variation in the performance of the demonstrated technologies. This variation can be attributed to agro-ecological factors such as weather fluctuations, soil fertility status, and pest incidence.

Comparable trends have been reported by Kumar *et al*. (2010) [7] and Jha *et al*. (2020) [6], underscoring the need for context-specific technological interventions to enhance agricultural productivity.

Economics

Economic considerations are crucial determinants in the adoption or rejection of agricultural technologies, shaped by factors such as seed yield, input costs, labour expenses, and market prices for outputs. The economic analysis conducted during the study period clearly indicated that the adoption of recommended practices led to significantly higher gross returns (Rs. 59,059 ha^{-1}), net returns (Rs. 22,750 ha^{-1}), and a benefit-cost ratio (1.62) compared to traditional farmer practices, which yielded Rs. 47,151 ha^{-1} in gross returns, Rs. 10,144 ha^{-1} in net returns and a B:C ratio of 1.29. The relatively lower economic returns observed in 2023-24 were primarily attributed to reduced seed yields. These findings are consistent with the results reported by Sanjay *et al*. (2020) [6].

Fig 1: Cluster Frontline Demonstrations of Blackgram at Kothuru (V), Kaligiri (M) in the Year 2022-23

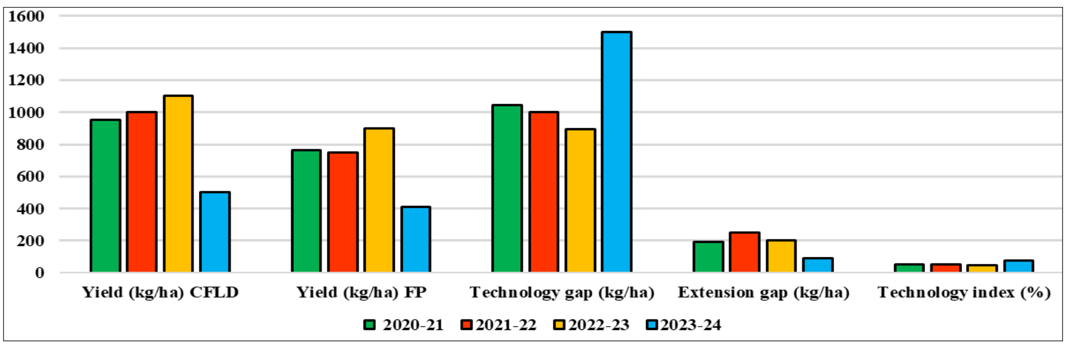

Fig 2: Impact of Technological Intervention on Yield of Blackgram and Gap Analysis

Conclusion

Cluster Frontline Demonstrations (CFLDs) on blackgram variety TBG-104 have significantly contributed to reducing the technology gap and enhancing productivity through the adoption of scientific cultivation practices. By supplying quality inputs and imparting essential knowledge, CFLDs have enabled farmers to realize the crop's yield potential. The introduction of high-yielding varieties, along with improved sowing methods, precise nutrient and weed management, and effective plant protection strategies, has resulted in substantial yield gains and higher economic returns. The favourable benefit-cost ratio observed under CFLDs underscores their economic viability and encourages wider adoption among farming communities. To sustain and scale these impacts, extension initiatives such as training programs, field days and exposure visits are imperative. Continued education and technical support are especially vital for resource-poor farmers to improve blackgram productivity, diversify their cropping systems and enhance their livelihoods.

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