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Correlation and Performance Analysis of Frontline Demonstrations of Blackgram in Different Districts of Punjab, India

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ABSTRACT

Background: Blackgram, being less water requiring and nitrogen fixing crop, not only improves soil health but also facilitates the concept of crop diversification in the intensive cropping system. Adoption of improved cultivars and production technology can prove fruitful in harnessing the genetic potential of blackgram in varied agro-ecological conditions.

Methods: The study involves the frontline demonstrations of improved production technologies of blackgram in 6 districts of Punjab *viz*., Amritsar, Gurdaspur, Moga, Pathankot, SAS Nagar and SBS Nagar during Summer 2025, as per the action plan finalized by the Director, ICAR-ATARI, Zone-I, Ludhiana. Total 60 frontline demonstrations were conducted with 10 demonstrations per district after conducting the baseline survey of 90 farmers (15 farmers per district). The baseline survey was conducted to have an idea about the production techniques followed by the farmers such as variety, method of sowing, seed rate *etc*. The demonstrations were conducted to study the performance of improved production technologies of blackgram in 6 districts in terms of grain yield by deriving extension indices such as extension gap, technology gap and technology index relative to the farmers' practices (FPP) and principle component analysis.

Result: In overall scenario, demonstration plot recorded 19.98, 17.50 and 29.70% higher number of pods, 1000-grain weight and grain yield than FPP, respectively. The pod length and number of seeds per pod were statistically at par in demonstration and FPP. The demonstration plot registered significantly higher net returns (Rs. 58214.19/ha) as well as B:C (2.80) than FPP *i.e*., Rs. 39028/ha and 1.85, respectively. Districts reported varied levels of extension indices such as highest extension gap (3.5 q/ha) was observed in Moga district with minimum value in case of SBS Nagar. Principle component analysis revealed that yield attributes like number of pods per plant, seeds per pod and 1000-grain weight exhibited positive correlation of 0.589, 0.605 and 0.572 with grain yield of blackgram. Conclusively, the results imply that improved production technologies play pivotal role in realizing high productivity, monetary returns and achieving sustainability.

Key words: Blackgram, Extension gap, Frontline demonstrations, Grain yield, Principle component analysis, Technology gap.

INTRODUCTION

The word "Pulse" is derived from a Latin word "Puls" means pottage *i.e*., grains boiled to make a thick soup (Kanavi *et al*., 2020). Blackgram [*Vigna mungo* (L.) Hepper] (Urd), the third most important pulse crop in India, is cultivated in a diverse range of agro-climatic conditions. In general, *Urd* is taken as 'Dal' but it is a major ingredient in '*papad*, *idly* and *dosa*' making (Jayaramasoundari, 2024). It is rich source of proteins (25-26%), carbohydrates (60%), fat (1.5%), minerals and amino acids (Meena and Ram, 2016) and water soluble vitamins (Chaudhary *et al*., 2018) and helps restoring the soil health by fixing the atmospheric nitrogen (Rathi *et al*., 2009) thereby meeting 80% of its N requirements (Gourav *et al*., 2026). Furthermore, less water requirement of blackgram effectively supports the rationale of crop diversification and sustainable crop production in Punjab (Singh, 2023). The downfall in the production of pulses has affected the nutritional security as well as gave rise to issues like poor soil health, over use of underground water and monoculture *etc*. Moreover, arising sustainability issues have revived the interests to promote pulse crops as possible alternates. The existing gap between genetic potential and the actual realization of grain yield may be

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due to improper application of recommended techniques (Amuthaselvi *et al.*, 2023) which in turn pose challenge to the research and extension systems. Thus, it needs to have firm extension programs to sensitize the stakeholders regarding the adoption of latest production techniques (Parmar *et al.*, 2017). The front line demonstrations (FLDs), being an important tool, play pivotal role in assessing the performance of improved techniques (Singh and Tetarwal, 2022 and Ali *et al.*, 2023) and transferring them to the actual field conditions (Singh and Sharma, 2018). FLDs render avenues to the experts to exhibit the yield potential and economic viability of latest production practices at farmer fields (Teggelli *et al.*, 2015) and horizontal expansion of improvised technologies (Jaidka and Brar, 2024). Therefore, exhibiting the advantages of new practices, FLDs act as connecting link to bridge the gap between research and actual methodology for improved productivity and ensured food availability (Singh *et al.*, 2025) while increasing the energy output (Jaidka *et al.*, 2025). Keeping in view the immense potential of frontline demonstrations and economic importance of blackgram, 6 Krishi Vigyan Kendras of Punjab conducted frontline demonstrations of blackgram in the state during Summer 2025 with an objective to assess the performance of blackgram in different districts of the state and to study the district-wise need of the extension programs based on indices such as extension gap, technology gap, technology index.

MATERIALS AND METHODS

The present study involves the frontline demonstrations (FLDs) of improved production technologies of blackgram (Table 1) conducted by 6 Krishi Vigyan Kendras *viz.*, Amritsar, Gurdaspur, Moga, Pathankot, SAS Nagar and SBS Nagar during Summer 2025.

The demonstrations were conducted on 60 locations in the state with 10 locations per district (Fig 1) as per the action plan finalized by the Director, ICAR-ATARI, Zone-I, Ludhiana. The performance of the demonstrations was assessed in terms of growth, grain yield and yield attributes.

Baseline survey

In the action plan, it was decided to conduct a baseline survey of 15 farmers per KVK (total 90 farmers) in respective district to collect the information pertaining to the area under Summer crops, varieties of blackgram cultivated, source of seed, sowing time, seed rate, method of sowing *etc.* The data collected was processed to have an idea about the actual scenario of production technology followed by the farmers. Results of the baseline survey showed that 11% farmers cultivate blackgram during Summer season out of which 42% farmers cultivate recommended varieties while 58% go for un-recommended locals (Fig 2). About 27% farmers use recommended seed rate (50 kg/ha) with flat or bad planting while 73% farmers sow the crop with broadcasting method by using the seed rate less than the recommendation. The recommended dose of urea and phosphatic fertilizer is applied by 25 and 15.4% farmers, respectively.

While laying down the demonstrations, the farmers were sensitized regarding the improved production technologies through training programmes, farm literature and personal contacts. The demonstration plots were regularly visited by the KVK experts for monitoring of the crop health and need based advisory. The growth and yield parameters such as plant height, number of pods per plant, number of seeds per pod, pod length, grain yield were recorded from the demonstration as well as FPP. The economic analysis was also performed to determine the benefit cost ratio. Further, the extension indices such as extension gap, technology gap, technology index were calculated by using the formula given below (Jaidka *et al.*, 2024):

$$\text{Extension gap} = \text{Demonstration yield} - \text{Farmers' yield}$$

$$\text{Technology gap} = \text{Potential yield (11.25 q/ha)} - \text{Demonstration yield}$$

$$\text{Technology index} = \frac{\text{Technology gap}}{\text{Potential yield (11.25 q/ha)}} \times 100$$

Statistical analysis

The statistical procedure to compare the means was performed on the online OPSTAT software at 5% level of significance. Correlation matrix was calculated by through principle component analysis (PCA) to understand the nature and intensity of relationships among the dependent and independent variables.

Table 1: Details of demonstrations and farmers' practices (FPP).

Agronomic practice	Demonstration	Farmers' practice (FPP)
Variety	Mash 1137	Local cultivar
Seed inoculation	Seed inoculated with *Rhizobium* culture	No seed inoculation
Seed rate	50 kg/ha	20-30 kg/ha
Sowing time	15th March-1st week of April	15 February-Mid April
Method of sowing	Line sowing at R-R 22.5 cm	Broadcasting
Fertilizer application	Urea: 27.5 kg/ha; SSP:150 kg/ha	As per the farmer experience
Weed management	Hand weeding at 30 DAS	No weeding or Hand weeding
Plant protection	Need based application of recommended pesticides	Use of pesticides as per farmers' choice

RESULTS AND DISCUSSION

Growth and yield attributes

The data revealed a district wise variation in plant height of blackgram in farmers' practices (FPP) relative to demonstration plot (FLD) (Table 2). For instance, district Amritsar, Gurdaspur, Moga and SAS Nagar registered 13.72, 21.20, 9.43 and 10.54% less and significantly different plant height in demonstration plot as compared to FPP. On the contrary, the demonstration plot and FPP reported statistically equal plant height in remaining 4 districts viz., Pathankot and SBS Nagar. More plant height in FPP in former districts can be due to non-judicious use of fertilizers and irrigation water which led to the increased vegetative growth. But use of recommended dose of fertilizers (Jayaramasoundari, 2024) in demonstration plot maintained the balance between demand and supply of the nutrient, which in turn resulted in the short plant stature. Further, statistically equal plant height in FPP and FLD in remaining 4 districts can be attributed to the occurrence of high seasonal rainfall. Maintenance of high soil moisture regime results in more vegetative growth in pulse crops (Jaidka and Deol, 2024) leading to increased plant height. The overall scenario reported statistically equal plant height of blackgram in FLD and FPP. The data pertaining to

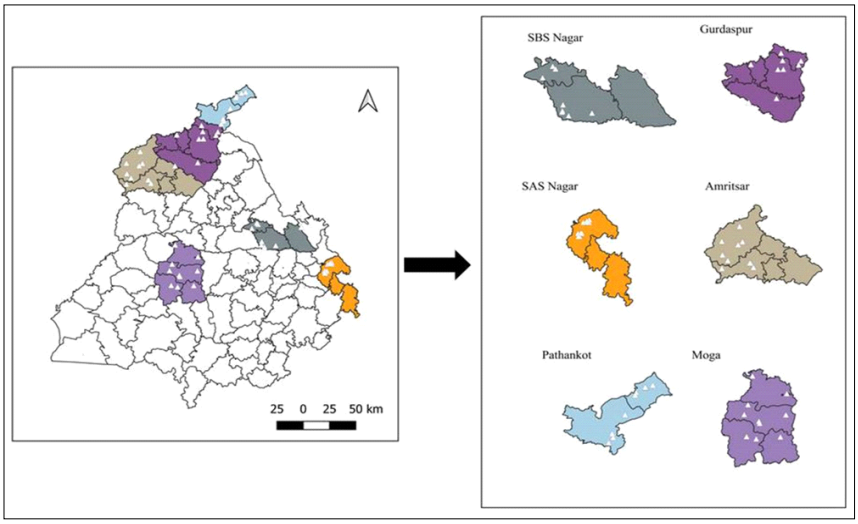


Fig 1: GPS locations of frontline demonstrations of blackgram in 6 districts of Punjab.

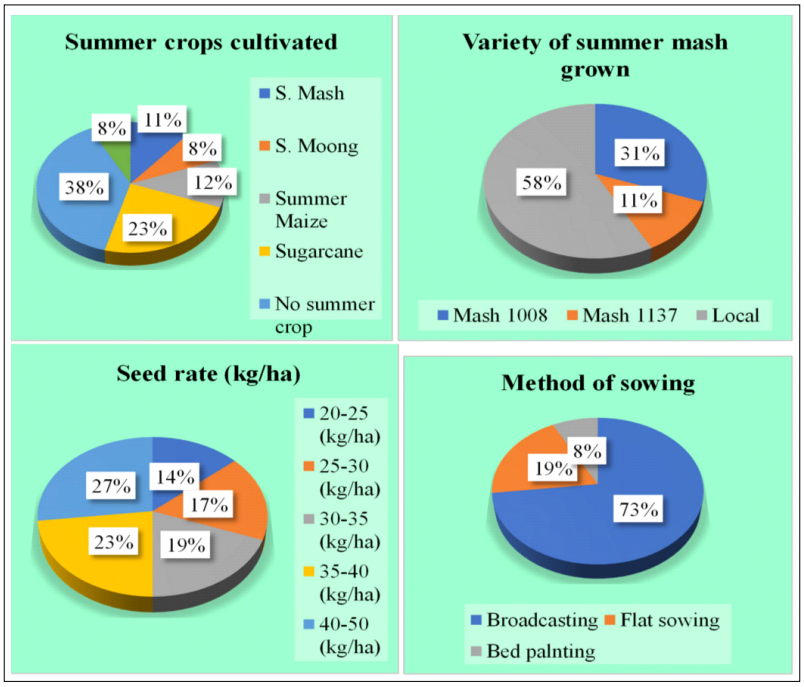


Fig 2: Observations recorded in the baseline survey conducted by the KVKs.

Table 2: Growth and yield attributes of blackgram in different districts of Punjab.

District	Plant height (cm)		p (0.05)	SE (d)	Pods length (cm)		p (0.05)	SE (d)	Seeds/ pod (Nos.)		p (0.05)	SE (d)	Pods/ plant (Nos.)		p (0.05)	SE (d)
	Demo	FPP			Demo	FPP			Demo	FPP			Demo	FPP		
Amritsar	37.10	43.00	0.0004	0.46	4.51	4.39	0.1775	0.05	6.90	6.60	0.1623	0.15	19.22	15.90	0.0009	0.28
Gurdaspur	40.50	51.40	0.0001	1.51	4.36	4.42	0.4963	0.07	6.10	5.40	0.2713	0.09	19.70	15.70	0.0004	0.37
Moga	33.60	37.10	0.0066	0.82	4.53	4.43	0.3405	0.07	6.93	6.47	0.0953	0.20	20.70	16.80	0.0088	0.94
Pathankot	34.30	36.10	0.1309	0.78	4.48	4.51	0.8061	0.08	5.70	5.30	0.0831	0.13	19.17	14.50	0.00003	0.50
SAS Nagar	33.10	37.00	0.0045	0.84	4.51	4.52	0.9460	0.07	6.60	5.80	0.0672	0.13	18.63	16.45	0.0009	0.39
SBS Nagar	44.10	45.50	0.2983	0.92	4.39	4.47	0.5486	0.09	6.50	6.20	0.1224	0.17	18.09	17.15	0.0313	0.45
Over all	37.12	41.85	0.1556	2.17	4.46	4.45	0.8564	0.03	6.46	5.96	0.1276	0.21	19.25	16.08	0.0001	0.38

the pod length and number of seeds per pod showed non-significant difference between the demonstration and FPP in all the districts as well as in the overall analysis. The recommended variety of blackgram in the demonstration plot consistently outperformed the local check in FPP in terms of the number of pods per plant in all the districts as well as in the district average. For example, Amritsar, Moga and SBS Nagar districts showed 20.88, 23.21 and 5.48% higher number of pods per plant in FLD than FPP, respectively. The high number of pods per plant in FLD reflects the genetic superiority of recommended variety of blackgram than local check (Meena and Ram, 2016) in all the districts of Punjab. The decrease in number of pods in FPP than FLD can be attributed to high fertilizer use coupled with the non-judicious use of irrigation water which results in more plant vigour creating competition between vegetative and reproductive parts for the assimilates leading to more allocation of the photosynthates towards the vegetative development at the expense of reproductive organs (Buttar and Aggarwal, 2004) consequently causing the abscission of flowers and pods. On the contrary, following the improved production technology (Hada *et al.*, 2021) such as nutrient management, water management *etc*. tries to maintain the balance between demand and supply without posing any detrimental effect on the progressive growth stages of the crop leading to increased number of pods per plant up to 27.04% (Amuthaselvi *et al.*, 2023).

Grain yield and economics

The cultivation of recommended variety following the improved production technology in the demonstration plot magnificently enhanced the 1000-grain weight (Table 3) in all the districts. The overall scenario also reported an increase in 1000-grain weight by 17.50% in FLD in comparison to FPP. The need based input use and proper growth regulation in the pulse crops by adopting latest production technologies (Mishra *et al.*, 2025) maintains sufficient supply of the assimilates to the developing grains. Thus, cultivation of improved variety coupled with grain inoculation (Rathi *et al.*, 2009) and site specific input management in the FLDs resulted favourable plant architect which in turn prompted efficient translocation of assimilates to the developing reproductive parts *i.e.*, grains, thus the demonstration plot significantly out yielded the FPP in all the districts. Amritsar and Pathankot districts exhibited an increase in grain yield by 31.65 and 40.54%, respectively. Pulse crops show an evolutionary behaviour of indeterminate growth habit which, if not managed well, leads to competition between vegetative and reproductive parts (Jaidka *et al.*, 2018), which gives rise to physiological lacunas such as poor allocation of assimilates towards sink, flower and fruit drop and poor pod setting (Sengupta and Tamang, 2015). In this case, maintaining the synchrony between new leaves and developing pods is the key to realize better economic output. Thus, practicing the latest cultivation techniques such as improved variety, nutrient

Table 3: Grain yield and economics of blackgram in different districts of Punjab.

District	1000-Grain weight (g)		p (0.05)	SE (d)	Grain yield (q/ha)		p (0.05)	SE (d)	Net returns (Rs/ha)		p (0.05)	SE (d)	B:C		p (0.05)	SE (d)
	Demo	FPP			Demo	FPP			Demo	FPP			Demo	FPP		
Amritsar	41.89	34.47	0.0003	0.67	10.40	7.90	0.0001	0.18	58166.70	38338.80	0.00003	1810.82	2.90	1.90	0.00002	0.09
Gurdaspur	42.07	34.50	0.00001	0.89	10.60	7.90	0.00002	0.18	59004.30	37766.10	0.0007	2038.19	2.90	1.80	0.00001	0.10
Moga	43.29	36.71	0.0003	0.59	11.50	8.03	0.0007	0.18	65255.80	37688.10	0.00002	1540.44	3.16	1.83	0.000005	0.10
Pathankot	41.93	33.00	0.00001	0.43	10.40	7.40	0.00001	0.18	60928.00	34670.50	0.00004	2054.47	2.90	1.70	0.000001	0.08
SAS Nagar	41.70	36.50	0.0002	0.80	10.00	8.00	0.00006	0.14	53686.80	38867.30	0.00001	1072.35	2.50	1.80	0.00009	0.05
SBS Nagar	40.20	37.70	0.0041	0.54	9.40	8.40	0.0052	0.43	50443.40	42409.60	0.00002	447.21	2.50	2.10	0.000005	0.02
Over all	41.85	35.48	0.00002	0.58	10.38	7.94	0.00001	0.22	57914.17	38290.07	0.00001	1465.81	2.81	1.86	0.000001	0.08

management (Kumpawat, 2010) and grain inoculation (Rathi *et al.*, 2009) can result in enhanced grain yield of blackgram by 22.83 (Borde *et al.*, 2023), 23.14% (Jayaramasoundari, 2024) as compared to FPP. Furthermore, the demonstration plots reported significantly higher net returns and B:C in all the districts over FPP. In intensive cropping systems, achieving the maximum possible yield levels of pulse crops at minimum cost of cultivation plays pivotal role in making their cultivation economically viable. In this context, selection of high yielding varieties along with efficient management practices viz., method of sowing, plant protection *etc*. prove promising in increasing the monetary returns by 47.37 (Singh *et al.*, 2025) and 26.33% (Singh *et al.*, 2024).

Extension indices

Extension gap depicts the technical competency of the farmers regarding any technology and gives an idea about requirement of sensitization of farmers for the given technology. High extension gap indicates more difference between outcomes of farmers' practice and the intervention demonstrated and vice-versa. The data revealed that highest extension gap was recorded in Moga (3.5 q/ha) district followed by Pathankot (3.0 q/ha) and Gurdaspur (2.7 q/ha) (Table 4). High extension gap means better performance of improved variety which in turn shows more scope for horizontal spread of the improved variety and production technology along with need to concentrate the extension programmes (Singh and Singh, 2020) so as to bridge the gap of 3.6 q/ha (Gourav *et al.*, 2026). On the contrary, less extension gap in districts such as SAS Nagar (1.9 q/ha) and SBS Nagar (1.0 q/ha) reflects that although improved variety registered an increase in grain yield but the margin was less relative to the FPP. Technology gap shows the level of cooperation or coordination of the farmers in practicing the improved production technology in the demonstration plot. High technology gap means less interest showed by the farmers in following the improved production technology, as a result of which the improved variety/technology could not perform well leading to widen the gap between the potential yield and demonstration yield. Data revealed that minimum technology gap was observed in Moga district (-0.3 q/ha) followed by Gurdaspur (0.7 q/ha) and Pathankot (0.9 q/ha). Negative technology

Table 4: Extension indices of demonstrations in different districts of Punjab.

District	Extension gap	Technology gap	Technology index
Amritsar	2.5	0.8	7.5
Gurdaspur	2.7	0.7	5.8
Moga	3.5	-0.3	-2.2
Pathankot	3.0	0.9	7.9
SAS Nagar	1.9	1.3	11.3
SBS Nagar	1.0	1.8	16.3
Over all	2.4	0.8	6.9

Table 5: Multivariate analysis of correlation between dependent and independent variables (on the basis of overall analysis).

Parameters	Plant population	Plant height	Pods/Plant	Seeds/Pod	1000-Grain weight	Grain yield
Plant population	1.000	0.082	0.233	0.622	0.523	0.542
Plant height		1.000	-0.635	0.252	0.110	-0.130
Pods/plant			1.000	0.089	0.070	0.589
Seeds/pod				1.000	0.376	0.605
1000-Grain weight					1.000	0.572
Grain yield						1.000

gap clearly reflects the high level of cooperation to follow the improved technology to cultivate the new variety due to which it surpassed the potential yield (11.25 q/ha). More technology gap means more deviation from the potential yield. The variation in the agro-ecological conditions of technology evolved and technology adoption led to the technology gap of 5.22 (Annu *et al.*, 2026) and 2.67 q/ha (Singh *et al.*, 2026). The technology index reflects the feasibility of the improved variety or technology at farmer field. Low technology index means high feasibility and vice-versa. Data revealed minimum technology index in Moga district (-2.2) which shows that better performance and practicability of improved variety of blackgram in the district. On the contrary, high technology index in SBS Nagar (16.3) and SAS Nagar (11.3) exhibits less realization of economic output. High technology index can be due to differences in the soil fertility, less interest to follow the improved technology *etc.* which can lead to increase in technology index up to 23.60 (Hashim *et al.*, 2026).

Principle component analysis

Yield attributes such as number of pods per plant, seeds per pod and 1000-grain weight exhibited positive correlation of 0.589, 0.605 and 0.572 with grain yield of blackgram (Table 5). The negative correlation between plant height and grain yield can be justified in terms of negative correlation between plant height and number of pods per plant (-0.635). Genetic superiority of the improved variety registered lesser plant height and more number of pods per plant. Further, adoption of need based input application and crop management practices also maintained the balance between vegetative and reproductive parts for efficient translocation of assimilates towards developing pods in the demonstration plot. On the contrary, non-judicious use of fertilizers and irrigation water increased the plant height due to indeterminate growth habit and excessive plant foliage which put in effect the competition between newly forming leaves and floral buds causing the abscission of floral buds and pods in FPP. It can be summarized that plant height showed negative correlation with grain yield indirectly though shedding of reproductive parts as abscission of pods registered negative correlation of -0.1868 and -0.1846 grain yield of soybean during 2014 and 2015, respectively (Jaidka and Deol, 2024).

FUTURE THRUST

The nature of production technology followed in crop production is greatly affected by the soil type and prevailing region specific weather conditions. In this context, there is need to assess the performance of crop in different soil types while observing the weather regimes in different districts to have an idea about the effect of particular set of agro-ecological conditions on the productivity of the blackgram.

CONCLUSION

The frontline demonstrations of blackgram following the improved variety and production technology at farmers' field clearly point outs the significance of practicing the latest need based crop management practices in realizing better economic output. The results also take the side of the farmers in the baseline survey who cultivate recommended variety of blackgram by using seed rate of 45-50 kg/ha in line sowing (recommended practices) although majority of the farmers opt for local variety (58%) and broadcasting of seed using less than recommended quantity (73%). Achieving the higher grain yield in the demonstration plots than FPP firmly supports the 25 and 15.4% farmers in the baseline survey who use recommended dose of urea and phosphatic fertilizers. The optimum use of the inputs also proves propitious in maintaining synchrony between vegetative and reproductive parts.

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Conflict of interest

Authors hereby declare that there does not lie any conflict of interest while publication of this manuscript.

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