J. Mountain Res. P-ISSN: 0974-3030, E-ISSN: 2582-5011 DOI: https://doi.org/10.51220/jmr.v19-i1.21
Vol. 19(1), (2024), 193-202

Economics and Yield Potential of Him Mash Variety of Black Gram (*Vigna Mungo* L) Under Rainfed Conditions in Himachal Himalayas, India

Renu Kapoor[1]* • Anurag Sharma[2] • Rajeev Raina[3] • Dharminder Kumar[1] • Sushil Dhiman[3] • Kehar Singh Thakur[3] • Jaya Chaudhary[3]

[1]*Regional Horticultural Research and Training Station, Jachh (Kangra), Dr. YS Parmar University of Horticulture and Forestry (HP) 176201.*
[2]*HRTS and Krishi Vigyan Kendra (KVK), Kandaghat, Dr. YS Parmar University of Horticulture and Forestry (HP).*
[3]*Krishi Vigyan Kendra, Chamba, Dr. YS Parmar University of Horticulture and Forestry (HP).*

*Corresponding Author Email id: rnkapoor56@gmail.com

Received: 10.04.2024; Revised: 10.06.2024; Accepted: 11.06.2024

Abstract: The study was conducted with the objective to evaluate the performance of improved variety of black gram (Him Mash-1) with scientific practices through cluster front line demonstrations at farmer's field in District Chamba. Cluster Front Line demonstration is an appropriate means to transfer the improved agriculture technologies to farmers to bridge yield gaps and to receive direct feedback. Farm Science Centre, Chamba laid out a total of 124 demonstrations. Black gram cv. Him mash-1 was demonstrated against the local variety (2018-2019) where as in the year 2020, Him mash-1 variety with scientific practices was demonstrated. The front-line demonstration recorded 37.14 and 37.5 percent increase in yield over check during the years 2018 and 2019, respectively. However, in the year 2020 when improved variety of black gram along with scientific practices demonstrated, the technology gap decreased from 10.20 to 6.40 q ha^{-1} but extension gap increased with increase in yield. The technology index decreased from 68.00 to 42.66 percent during the years 2018 to 2020, which shows the higher feasibility of the demonstrated technology in the district. Demonstrations further improved the benefit cost ratio and have also increased water use efficiency with the same amount of seasonal water use.

Key words: cluster front line demonstration • extension gap • technology gap • technology index • water use efficiency.

Introduction

Pulses are major source of dietary protein in a vegetarian diet in our country and have a wide range of adaptability to latitudes, longitudes and climatic variability (Singh et al. 2019). Pulses occupies unique place in India's nutritional food security for ever growing population and also to the weaker sections of the society who could not afford other sources of protein (Singh et al. 2020). Pulses are low in fat and rich in soluble fiber, which can lower cholesterol and help in the control of blood sugar (Ghosal and Sahu 2018). India, with a share of 22 percent, is the largest producer of pulses in the world (Sangeetha et al. 2020). During 2018-2019, it was cultivated in an area of 29.16 million ha with production of 22.08 million tons at productivity level of 757 kg ha^{-1} (Anonymous 2020). The productivity of pulses in Himachal Pradesh is far below the average national productivity mainly because of lack of awareness in farming community regarding improved package of practices. Other factors like lack of improved varieties, agronomical/plant protection practices, climatic conditions are also responsible for low productivity of pulses (Kumar and Dev 2020). Though pulses have several advantages in a sustainable farming system, it has not been viewed as a profitable farm enterprise. Being a leguminous crop, pulses have the ability to fix atmospheric nitrogen and thus restoring the soil health by improving the soil fertility and also suitable for inter-cropping with different crops (Singh et al. 2017). The productivity of pulses per unit area could be increased by adopting feasible scientific management practices with improved varieties.

The "black gram" is an important pulse crop which contains protein almost thrice that of cereals. Black gram is an annual leguminous crop belongs to family Fabaceae and is an important kharif pulse crop consumed in the form of "daal" (whole/split, husked/un-husked). Black gram is rich source of protein (25-28%), carbohydrates (62-65%), fibre (3.5-4.5%), ash (4.5-5.5%), oil (0.5- 1.5%), amino acids like lysine, vitamins like thiamine, niacin, riboflavin and much needed iron and phosphorus (Sohel et al. 2016). The problem of malnutrition among the economically backward farming community can be minimized by increasing the consumption of pulses which are a rich source of proteins, minerals, iron and fibre. Keeping the cheapest source of protein and its contribution to sustainable farming system, it is important to increase pulses acreage and productivity. To increase the productivity and area under pulses throughout India, Indian Council of Agricultural Research, New Delhi has given the task to Farm Science Centers to introduce new high yielding variety of pulses with best management practices through cluster frontline demonstrations (CFLDs). Farm Science Centers (Krishi Vigyan Kendras) are grass root level organization meant for application of technology through assessment, refinements, dissemination and demonstrations of proven technologies under different micro farming situation in the district (Das 2007). Frontline demonstrations are important dissemination process for transfer of technology through demonstrations on farmer's field to bridge yield gaps, which ensures better livelihood, high nutritional security and economic empowerment of marginal farmers. Keeping in view the above consideration, cluster front line demonstrations were carried out on farmers' field by Farm Science Centre, Chamba (KVK, Chamba). The main objective of the study was to demonstrate the improved technologies and convincing the farmers about potentialities of improved production technologies of black gram for further adoption.

Material and Methods

Realizing the importance of cluster frontline demonstrations in transfer of latest technologies, Farm Science Centers are regularly conducting CFLDs on pulses at farmer's field. The CFLDs were conducted in the District Chamba of Himachal Pradesh, India by Farm Science Centre, Chamba working under Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni (Solan). District Chamba is situated between North latitude 32°11' and 33°13' and East longitude 75°49' and 77°3', at an altitude 645-6776 m amsl and is surrounded on all sides by lofty hill ranges. The mean annual rainfall of the study area is about 1200 mm. The agro climatic zone is sub temperate, sub humid, mid hills and cereal, pulse, fruit, vegetable-based cropping systems are predominant in this zone.

Traditionally black gram is grown either as main crop or inter-cropped with maize by small and marginal farmers for food and fodder in Chamba District. The CFLD's were conducted to study the yield gap, extension gap, technology gap and technology index. A total of 124 demonstrations covering 30 ha area were conducted consecutively for three years under cluster front line demonstrations programme during *kharif* 2018 to *kharif* 2020 under *rainfed* conditions in selected cluster villages of District Chamba. In the year 2018 and 2019 *Him mash-1* variety of black gram was demonstrated against check (local variety along with farmer's practice) where as in the year 2020 *Him mash-1* variety along with other package of practices were also demonstrated (Table 1) against check (*Him mash-1* variety along with farmer's practice).

Table 1. Details of front-line demonstrations and check in the year 2020

Particular	Demonstration	Check (Farmer's Practice)
Variety	*Him mash-1*	*Him mash-1*
Seed rate	20 kg ha^{-1}	20 kg ha^{-1}
Seed treatment	Rhizobium biofertilizer	No seed treatment
Method of sowing	Kera/line	Broadcasting
Weedicide	Need based spray of weedicide	No application
Plant protection	Need based spray of fungicide insecticide	No application
Irrigation	Rainfed	Rainfed

Under demonstration the farmers were provided inputs like improved seed, biofertilizers and IPM inputs for weed, disease and insect control as per norms of the programme. Before conducting CFLD's farmers were trained to follow package of practices and method of seed inoculation with bio-fertilizer was also demonstrated to them (Fig. 1&2). Regular visits, advisory services and monitoring were done by KVK, Scientist's to demonstration plots right from sowing to harvesting. During the period field days were also organized at demonstration plots involving other farmers, extension officials to disseminate the message at large scale (Fig. 3). The traditional practices were followed by the farmers in case of check (farmer's practice).

Fig 1. Training Programme Conducted on CFLD's Pulses.

Fig 2. Method Demonstration of Seed Inoculation.

Fig 3. Field Day Organized at Farmer's Field.

Economics and yield gaps

Complete data was collected from farmers about demonstrations and check on crop yield and cost of cultivation. Cost of cultivation of Black gram includes cost of inputs like seed, biofertilizers, weedicide/fungicides/pesticides etc. provided by the KVK under demonstration and purchased by the farmers in case of check, fertilizers, ploughing and labour charges invested by framers itself. Accordingly, gross and net returns were worked out by taking into account cost of cultivation and price of black gram. Likewise, benefit-cost ratio was worked out as a ratio of net returns and corresponding cost of cultivation. Other parameters like technology gap, extension gap and technology index were estimated by using following formulae (Matharu and Tanwar 2018).

Technology Gap (kg ha^{-1}) = Potential yield (PY) - Demonstration yield (DY).

Extension Gap (kg ha^{-1}) = Demonstration yield (DY) - Farmer's yield (FY).

Technology Index (%) = (Technology gap (TG) / Potential yield (PY) x 100.

Likewise, percent increase in yield in the demonstration plot over check (farmer's practice) was worked out as per the following formula (Choudhary et al. 2009).

Increase in yield over check = Extension gap (TG) / Farmer's yield (FY) x 100.

Opinion of the farmers about technologies used under demonstration was also collected for further improvement in research and extension activities.

Water use and water use efficiency

Water use efficiency (WUE) was computed from yield per unit consumptive water use. Water use efficiency was worked out and expressed in kg ha^{-1} mm^{-1} of consumptive water used. The consumptive water use was calculated by using following equation (Choudhary and Suri 2014).

Consumptive Water Use = I + ER ± ΔS

Where, I is irrigation water applied, ER is effective rainfall and ΔS is profile water contribution/depletion. The profile water contribution/depletion (ΔS) was not considered both in demonstration plots and farmers' plots due to the varying agro-ecological conditions. As the study was undertaken under rainfed conditions so no irrigation water applied. Thus, water use efficiency was worked out by taking in to account the effective rainfall received during the crop growth period (week 2 to week 15) from the Agro meteorological Observatory at Chamba (Fig. 4).

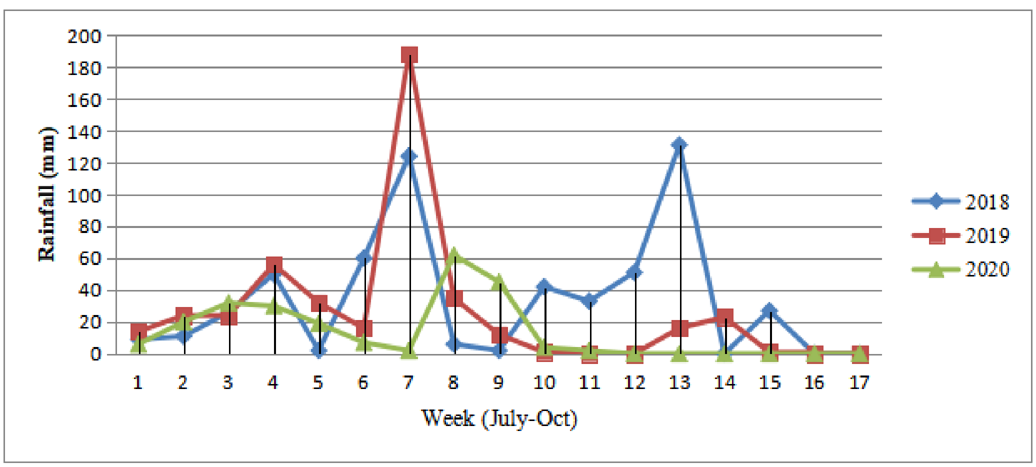

Fig 4. Rainfall pattern in the study area for the month of July to October (2018-2020).

Results and Discussion

Crop Yield: The results indicated that the cluster front line demonstration of improved variety of black gram cv *Him mash* -1 recorded higher crop yield over check (local variety). The crop yield under different demonstrations varied from 3.4 to 6.2 q ha^{-1} and 3.4 to 6.5 q ha^{-1} during the year 2018 and 2019, respectively (Table 2).

During 2018-2019 averaged yields were 4.88 q ha^{-1} under demonstration plot and 3.55 q ha^{-1} under Check (farmers practice). The front-line demonstration recorded 37.14 and 37.50 percent increase in yield over check in the year 2018 and 2019, respectively. However, in the year 2020 when improved variety of black gram along with other scientific package of practices was demonstrated the crop yield (8.6 q ha^{-1}) increased to the extent of 76.23 percent. These findings are in the conformity with the results of study carried out by Choudhary (2013); Kumar et al. (2015); Jayalakshmi et al. (2018); Singh (2020). Yields of demo plots were higher because of adoption of technological interventions along with improved varieties. Seed inoculation with biofertilizer like Rhizobium culture was another major factor of higher yield under demonstration plot as yield enhancement in pulses through bio inoculation has also been reported earlier by various researchers (Rathore et al. 2007; Kant et al. 2016). Thus, the CFLD had a positive impact on farming community due to enhanced yield to a tune of 72.00 per cent during 2020 over check

Table 2. Yield and yield difference of pulses under demonstrations and check

Year/season	**Area (ha)**	**No. of Demo**	**Yield (q ha^{-1})**				**Percent increase over check**	**Technology Index %**
			Demo			Check		
			Max	Min	Mean			
Kharif 2018	10	30	6.20	3.40	4.80	3.60	37.14	68.00
Kharif 2019	10	30	6.50	3.40	4.95	3.50	37.50	67.00
Mean	10	30	6.35	3.40	4.88	3.55	37.32	67.46
Kharif 2020	10	64	9.00	8.20	8.60	5.00	72.00	42.66

Yield Gaps: Gomez et al. (1979) identified two kinds of yield gaps between experiment station and farmers' fields, of which Gap-1 is due to environmental differences and Gap -2 is due to difference between potential and actual farmers yields. This Gap-2 also known as the true research-extension gap mainly attributed to combinations of biological, technical and socio-economic constraints. Crop yield under front line demonstrations, check and potential yield of the crop was compared to estimate the yield gaps. The potential yield of black gram cv *Him mash* -1 was found to be 15 q ha^{-1}. Potential yield is determined by solar radiation, temperature, photoperiod, atmospheric concentration of carbon dioxide and genotype characteristics assuming water, nutrients, pests, and diseases are not limiting the crop growth (Keshri and Jahanara 2019). The technology gap is the difference between the potential yield and demonstration yield and it was observed 10.20 and 10.05 q ha^{-1} during 2018 and 2019, respectively (Fig. 5). It indicates that still there is gap in technology demonstration as a result of which the potential yield of the improved practices could not be reaped by the participating farmers. Results clearly observed that there is decrease in technology gap with demonstrated improved variety (*Him mash*-1) including other package and practices, line sowing, seed treatment with Rhizobium, weed management, disease and pest management during the year 2020. Further the technology gap observed may be attributed due to improper nutrient and water management at critical stages. As the study area is rainfed so proper irrigation not followed and as for nutrient management some of the farmer's did not follow the practice as they are resource poor farmer's and distribution of fertilizers was also not part of the programme. Other factors like marginal land holdings, dissimilarity in the soil fertility status, erratic rainfall and local climatic situation also contribute to the technology gap (Mishra et al. 2007).

Further the extension gap is the difference between demonstration yield and check yield, which was observed 1.2 and 1.45 q ha^{-1} during 2018 and 2019, respectively (Fig. 5). However, in the year 2020, higher extension gap (3.6 q ha^{-1}) was observed because crop yield of demonstrations increased due to adoption of other package of practices. The results of demonstrations clearly showed huge extension gap during the period under study. This also emphasized the need to educate the farmers through various extension means for the adoption of improved varieties along with package of practices to bridge the wide extension gap. Similar outcomes were also observed by Bairwa et al. (2013); Devi et al. (2018); Yadav et al. (2020); Kapoor et al. (2021); Kapoor et al. (2022).

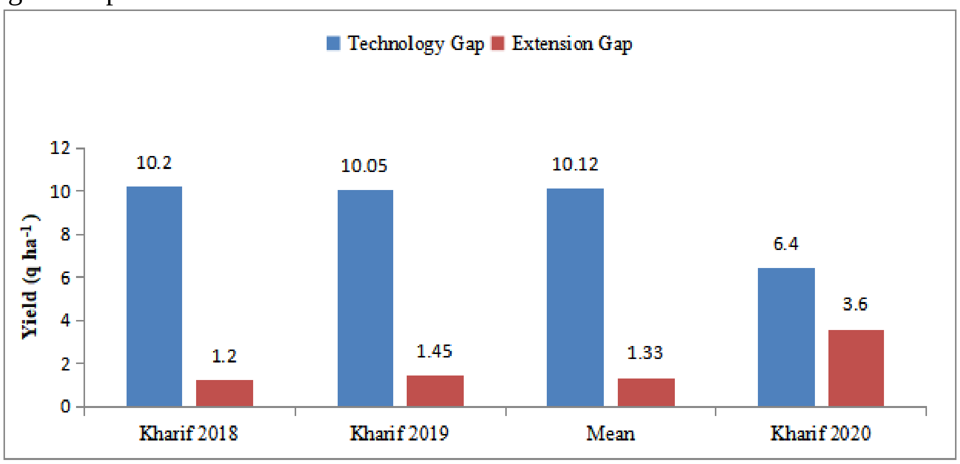

Fig 5. Yield gaps in black gram demonstrated under CFLDs and check

The technology index shows the feasibility of the improved technology at the farmer's fields and the success of any technology depends upon its feasibility under location-specific agro-climatic conditions for its large-scale diffusion (Kumari et al. 2007; Choudhary 2013). The lower is the value of technology index; the more is the feasibility of technology demonstrated. The technology index with the adoption of front-line demonstrations reduced from 68 to 42.66 % during consecutive years 2018 to 2020 respectively, which shows higher feasibility of the demonstrated technology in the district (Table 2). Technology indexes in blackgram (34.3-34.7%), kidneybean (32-37.5%), pigeonpea (47-50.6%), cowpea (68.8-73%), chickpea (59-65%), and lentil (44.3-60.2%) revealed that demonstrated technology under FLD-TTP is quite feasible in prevailing farming situations in Himachal Pradesh (Choudhary and Suri 2014). Other researchers also observed similar results in black gram (Singh et al. 2019; Singh et al. 2020).

Economics: Economic analysis of yield performance revealed that participating farmers in CFLDs realized higher prices compared to check during the period under study (Table 3). The gross cost of cultivation is Rs. 18,200 per ha during both the years and net return from demonstrated technology is ranged from Rs 29,800 to Rs 33,000 per ha in the year 2018 and 2019, respectively. Cost of cultivation increased in the year 2020 under demonstration due to extra cost of inputs used like Rhizobium culture, weedicide, fungicide/insecticide and fertilizers. Besides high cost of cultivation net profit was 90.77 per cent higher in demo (74,400 Rs. ha^{-1}) due to increase in yield compared to check (39,000 Rs. ha^{-1}). Similar findings were also reported in front line demonstrations on pulses by Dwivedi et al. (2014); Singh et al. (2018); Singh et al. (2020). The benefit cost ratio in demo plot was 1.6:1 and 1.81:1 during 2018 and 2019, respectively. Whereas, in the year 2020 the benefit cost ratio in demonstration plot was observed 3.1:1 almost doubled than previous years. The results clearly showed positive response of CFLDs over the existing practices towards enhancing the yield of pulses in the district due to technological interventions effect on yield. Hence, the awareness and adoption of recommended scientific package of practices have increased the socio-economic status of farming community of the district.

Table 3. Economics of front-line demonstrations and check

Year	Economics of demonstration (Rs. ha^{-1})				Economics of check (Rs. ha^{-1})			
	Gross cost	Gross return	Net return	B:C ratio	Gross cost	Gross return	Net return	B:C ratio
2018	18200	48000	29800	1.6	15600	32400	16800	1.07
2019	18200	51200	33000	1.81	15600	31900	16300	1.05
2020	24000	98400	74400	3.1	18200	57200	39000	2.14

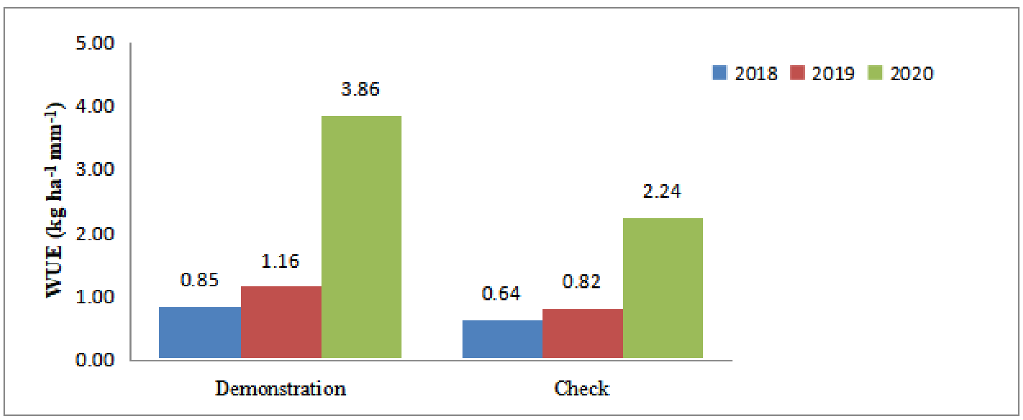

Fig 6. Water use efficiency (WUE) under demonstration and check during 2018-2020.

Water Use Efficiency: The rainfall pattern during the crop growth period (week 2 to week 15) has been greatly varied during the years 2018-2020, respectively (Fig. 6). Thus, the seasonal water use also varied 565 mm, 428 mm, and 223 mm during the years 2018-2020, respectively. The water use efficiency (WUE) varied between 0.85 to 3.86 kg ha^{-1} mm^{-1} under demonstration plots during the years under study (Fig. 6). This WUE was less during 2018-19, due to low yield against more water use and highest during 2020 due more yield against less water use. The improved technology has greatly enhanced the water-use efficiency (WUE) in the demonstration plots as compared to check (0.64 and 2.24 kg ha^{-1} mm^{-1}) though crop water use was same under both situations (Fig. 6). This was attributed due to improved crop yields under demonstration plots because of adoption of improved variety, seed inoculation with biofertilizers, better plant nutrition and plant protection measure resulting in higher WUE with the same amount of seasonal water use. Similar findings were also reported by Yadav et al. (2020); Choudhary et al. (2009). From the data, it is evident that improved farm technology

has greatly enhanced the WUE of pulses in demonstration plots over check
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Conclusion

It is concluded that by conducting cluster front line demonstrations of proven technologies, yield potential of pulse crop can be increased to a great extent by imparting scientific knowledge to the farmers, adopting scientific methods, providing the quality need-based inputs and their proper utilization. Thus, CFLDs has great potential to increase the productivity and profitability of farmers in the district. The demonstrated technologies also enhanced the WUE even under the rainfed situations. Results also indicated that there were wide technology gaps and extension gaps exist among potential yield, demonstration yield, and check yield. The reason may be environmental and some other management factors. This further needs to work on these factors with special attention on nutrient and water management at critical stages. Moreover, these technologies need to be popularized at large scale and beneficiary farmers of CFLDs may play an important role as source of information and quality seeds for wider dissemination among other farmers of the district.

Acknowledgement

The author's thanks ICAR-ATARI Zone I for providing financial assistance and DEE, Dr. YS Parmar University of Horticulture and Forestry, Nauni (Solan) for providing technical support for conducting frontline demonstrations and farmer's for conducting the investigations in their fields.

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