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Assessment of Cluster Front Line Demonstrations on the Yield and Economics of Mustard under National Food Security Mission in Bharatpur District of Rajasthan, India

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ABSTRACT

The study was conducted during *rabi* season (October–March) from 2016–17 to 2021–22 (6 consecutive years) in different villages of the Bharatpur district of Rajasthan to assess the performance of cluster front line demonstrations on mustard through improved varieties, seed rate, seed treatment, application of sulphur, disease and pest management on production and productivity. Krishi Vigan Kendra, Kumher, Bharatpur (Sri Karan Narendra Agriculture University, Jobner, Jaipur), Rajasthan conducted 800 front line demonstrations in an area of 320 ha on mustard crop variety DRMRIJ-31 (Giriraj) during 2016–17, 2017–18, 2018–19, 2019–20, 2020–21 and 2021–22. The results of study exhibited that the average yield under demonstrated plots ranged from 13.42 to 26.19 q ha^{-1} with a mean of 20.98 q ha^{-1}, which was 18.26% more yield as compared to farmer's practices (17.74 q ha^{-1}). The study showed mean extension gap of 323.83 kg ha^{-1}, mean technology gap of 602.33 kg ha^{-1} with mean technology index of 22.31%. Higher mean net return of ₹ 65064 ha^{-1} with mean benefit: cost ratio of 3.57 was found with improved technologies in comparison to farmer's practices (₹ 53760 ha^{-1}). Consequently, the results revealed that the adoption of improved technologies with scientific participation contributed to enhance the production and productivity of mustard in Bharatpur district.

KEYWORDS: Mustard, economics, extension-gap, DRMRIJ-31, technology-gap, technology-index, yield

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1. INTRODUCTION

Oilseed crops are India's second largest agricultural commodity after cereal crops, accounting for around 13.0% of gross cultivated area and 11.0% of total agricultural output value (Singh et al., 2023). In India, the two main oilseed crops are rapeseed and mustard during rabi season, both of which are critical to the nation's food and nutritional security. This crop is an important source of income for small and marginal farmers, mainly in rainfed areas of the country (Sangwan et al., 2021; Rathava et al., 2025). Rapeseed-mustard contributed roughly one-third of the country's edible oil among the nine primary oilseed crops (Langadi et al., 2021). Mustard oil is positioned as the third largest edible oil producing crop after soybean and palm oil in the world oil industry, while rapeseed and mustard oil occupies the first position in India (Gain et al., 2024). The mustard oil cake forms important cattle feed and furthermore, it also utilized as natural compost or manure or organic fertilizer (Swati et al., 2015; Thapa et al., 2019; Bairwa et al., 2022). Indian mustard is a significant oilseed crop, accounting for more than 80% of the country's total production of rapeseed mustard (Meena et al., 2014; Meena et al., 2015). Mustard can be grown in sandy to heavy clay soils (Pal et al., 2017). Sulphur is a critical element for mustard in determining its seed yield, oil content, quality and resistance to various biotic and abiotic stresses (Chahal et al., 2020; Heikal et al., 2022; Maurya et al., 2023; Ramya et al., 2023; Choudhary et al., 2024; Priyanka et al., 2025). Sulphur is vital for amino acid and protein production, oil synthesis, vitamin A component, and enzyme activation in plants (Li et al., 2020; Nakai and Nakashita, 2020; Maurya et al., 2023). In India, rapeseed-mustard grown in 9.18 m ha with production of 13.26 mt with average productivity of 1444 kg ha^{-1} (Anonymous, 2023). In Rajasthan, it is grown in 3.97 m ha with production of 5.83 mt and productivity of 1468 kg ha^{-1} (Anonymous, 2023). Rajasthan (46.13%), Uttar Pradesh (12.82%), Madhya Pradesh (12.26%), Haryana (10.29%), West Bengal (6.46%) and Gujrat (4.77%) are the top rapeseed-mustard producing states in India. Gujrat has the highest yield (1966 kg ha^{-1}) among the major oilseed producing states in India, followed by Haryana (1701 kg ha^{-1}), Madhya Pradesh (1540 kg ha^{-1}), Rajasthan (1468 kg ha^{-1}), and Tamil Nadu (233 kg ha^{-1}) (Anonymous, 2023). Krishi Vigyan Kendra (KVK) is a district level organization that assesses, refines, and disseminates demonstrated technologies in various micro farming situations throughout the district. The front line demonstration (FLD) is a useful approach to accelerate the dissemination of proved technologies at farmer's fields in a participatory mode with an objective to explore the maximum available resources of crop production. It is one of the most powerful tools of extension because farmers, in general, are driven by the perception that '*Seeing is believing*'. It is now realized that training of farmers increases the technical knowledge and awareness regarding improved cultivation technologies. Several biotic, abiotic and socio-economic constraints obstruct exploitation of the yield potential and these needs to be addressed. In this regards, Krishi Vigyan Kendra, Kumher, Bharatpur were conducted cluster frontline demonstrations on mustard crop during 2016–17, 2017–18, 2018–19, 2019–20, 2020–21 and 2021–22 in participatory mode in different selected villages of Bharatpur district of Rajasthan. The present study assessed the performance of cluster front line demonstrations on mustard through improved varieties, seed rate, seed treatment, application of sulphur, disease and pest management on production and productivity.

2. MATERIALS AND METHODS

The study was conducted during *rabi* season (October–March) from 2016–17 to 2021–22 (6 consecutive years) in different villages of the Bharatpur district of Rajasthan. Bharatpur district fell under Flood Prone Eastern Plain Zone-IIIB as per the Agro-climatic zones of Rajasthan. Total 800 FLDs on mustard were carried out by KVK, Kumher, Bharatpur of Rajasthan to harness of production potentiality of demonstrated mustard variety DRMRIJ-31 (Giriraj) along with full cultivation package of practices in 320 ha area. The technologies to be demonstrated for mustard were identified based on Participatory Rural Appraisal (PRA) technique. Under demonstration, 0.4 ha area was allotted for individual partner farmer and neighbouring 0.4 ha was considered as local check (farmer's practice). The partner farmers were trained to follow the improved technologies of mustard cultivation recommended for Flood Prone Eastern Plain Zone-IIIB. The required critical inputs like improved variety seed (DRMRIJ-31), for seed treatment-carbendazim and metalaxyl and for management of painted bug-malathion 5% or quinalphos 1.5% dust were supplied to the partner farmers from the available scheme budget and remaining inputs applied by the partner farmers themselves. The partner farmers were guided to use proper seed rate (5 kg ha^{-1}) with recommended package of practices. The line sowing method was demonstrated with 30×10 cm^2 spacing between rows and plants, respectively on farmer's field. For fertilizer management, 80 Kg N and 40 Kg P_2O_5 ha^{-1} were applied by the partner farmers through Urea and DAP or SSP. In addition to N and P_2O_5, sulphur at 25 kg ha^{-1} was supplied by the KVK for soil application as basal dose. Seeds were treated before sowing with carbendazim 50 WP and metalaxyl 35 SD at the rate of 2 g and 5 g kg^{-1} seeds, respectively, while weeds managed manually. Regular visits at the farmer's field by the KVK's scientists ensured proper guidance to the partner farmers (Hooda and Jangra, 2024; Sharma et al., 2024; Singh et al., 2023). During course of demonstrations for capacity building all the participating farmers were trained on various aspects of mustard production technologies. Field days and group meetings were also organized at flowering or maturity stage of the crop to provide the opportunities for other farmers to eyewitness the benefits of demonstrated technologies. Concurrently, feedback from the partner farmers also taken on the demonstrated technology. The partner farmers followed the full package of practices of mustard cultivation. In case of local check (farmer's practice), traditional practices were followed by using existing varieties or varieties from private companies. Data were collected from both the demonstration as well as farmer's practice plot of partner farmers through personal contacts with the help of well-structured interview schedule and the finally, extension gap, technology gap and technology index were worked out suggested by Samui et al. (2000) as per formula given below:

Per cent increase in yield=[{Demonstration yield (kg ha^{-1})-Farmer's practice yield (kg ha^{-1})}]÷Farmer's practice yield (kg ha^{-1})×100

Technology gap=Potential yield (kg ha^{-1})-Demonstration yield (kg ha^{-1})

Extension gap=Demonstration yield (kg ha^{-1})-Farmer's practice yield (kg ha^{-1})

Technology index (%)=[{Potential yield (kg ha^{-1})-Demonstration yield (kg ha^{-1})}]÷Potential yield (kg ha^{-1})×100

Economics of the demonstrations under improved technology and farmer's practice were recorded. Based on economics, additional cost, additional returns, effective gain and B:C ratios were calculated. These economic parameters were analysed using the formulae given below (Meena et al., 2022)

Additional cost (₹ ha^{-1})=Cost of cultivation of demonstration (₹ ha^{-1})-Cost of cultivation of farmer's practice (₹ ha^{-1})

Additional return (₹ ha^{-1})=Gross return of demonstration (₹ ha^{-1})-Gross return of farmer's practice (₹ ha^{-1})

Effective gain (₹ ha^{-1})=Additional return (₹ ha^{-1})-Additional cost (₹ ha^{-1})

B:C Ratio=Gross return (₹ ha^{-1})÷Cost of cultivation (₹ ha^{-1})

3. RESULTS AND DISCUSSION

3.1. Technology interventions versus farmer's practice

Before executing front line demonstrations at the farmer's field, participatory rural appraisal (PRA) was done. Based on this, major gaps were observed between improved technology and farmer's practice of mustard cultivation in Bharatpur district of Rajasthan (Table 1). These gaps were observed at the farmer's field are ascribed to the slow pace of extension activities, coupled with unreached extension system, poor accessibility of improved technologies especially among small holder farmer's and other vulnerable groups (Shivran et al., 2020). In farmer's practice, generally seed of local or old variety with low yield potential was sown instead of newly recommended varieties for the zone with improper application of improved recommended technologies. On the basis of observed gaps, under the demonstration improved variety seed, fungicides for seed treatment and insecticides for plant protection measures were provided to the partner farmers by the Krishi Vigyan Kendra (KVK) and other component namely, chemical fertilizers like N and P_2O_5 and all other crop management practices were timely performed by the partner farmer itself under the supervision of KVK's scientists (Leharwan et al., 2023; Parashar et al., 2022; Kumar et al., 2019).

Table 1: Technological gap between CFLDs and farmers` practices on mustard.

Component	Technological intervention	Farmers` practices
Variety	DRMRIJ-31	Existing/ Old recommended variety
Seed rate	5 kg ha^{-1}	20–25% higher
Seed treatment by chemical fungicide	Carbendazim 50 WP at 2 g kg^{-1} seed Metalaxyl 35 SD at 5 g kg^{-1} seed	10–15% farmers used Thiram/ Carbendazim as seed treatment
Fertilizer dose	Recommended dose of fertilizer (RDF)	Imbalance use of fertilizer
Plant protection measures	For management of painted bug-malathion 5% or quinalphos 1.5% dust at 25 kg ha^{-1}	Indiscriminate use of insecticide

3.2. Mustard yield

Under National Food Security Mission (Oilseeds), total 800 cluster frontline demonstrations of mustard were demonstrated during 2016–17 to 2021–22 in an area of 320 ha to showcase potential of demonstrated improved variety and performance of recommended package of practices in Bharatpur district of Rajasthan. The findings obtained during six year's demonstrations are presented in Table 2 revealed that the average seed yield of mustard through improved technology ranged from 13.42 to 26.19 q ha^{-1} as compared to 11.60 to 21.79 q ha^{-1} under farmer's practice. The mean average yield of total 800 demonstrations was 20.98 q ha^{-1} from improved technology whereas, the mean

Table 2: Grain yield and gap analysis of cluster front line demonstrations on mustard

Year	Village	Block	Variety	No. of demo.	Area (ha)	Yield of demo. (kg ha^{-1})		
						H	L	Av.
2016–17	Eklehra, Nawab Ka Nagla, Paprera, Sitara	Pahadi, Kumher	DRMRIJ-31	50	20	2200	2000	2100
2017–18	Nagla Sawai Ram, Baben, Maharawar, Luhasa, Songaon, Alamshah, Mahmadpur, Khadraya, Khohra, Satwas	Kumher, Nadbai, Deeg, Nagar, Weir, Bayana, Kaman,	DRMRIJ-31	125	50	2463	2119	2285
2018–19	Badangarh, Nagla Manjhi, Kanchanpura, Rundh Ikaran, Pana, Eklehra	Deeg, Kumher, Bharatpur, Roopwas, Pahadi	DRMRIJ-31	150	60	2738	2529	2619
2019–20	Borai, Ajaypura, Jarhara, Nangla Baghera, Bhatpura, Kheda Karoli, Janoothar, Khohra, Goojar Balai, Padalwas	Kumher, Deeg, Bayana, Roopwas, Nagar	DRMRIJ-31	200	80	1420	1280	1342
2020–21	Badangarh, Kanchanpura, Ajaypura, Sikrori, Maharawar, Bansi Kalan, Satwas, Moroli Khurd	Deeg, Kumher, Sewar, Kaman, Bharatpur	DRMRIJ-31	225	90	2750	1900	2250
2021–22	Borai, Sabora	Kumher	DRMRIJ-31	50	20	2500	1750	1990
Mean	-	-	-	-	-	2345	1930	2098
Total	-	-	-	800	320	-	-	-

Year	Village	Block	Average yield under FP (kg ha^{-1})	% increase in yield over FP	EG (kg ha^{-1})	TG (kg ha^{-1})	TI (%)
2016–17	Eklehra, Nawab Ka Nagla, Paprera, Sitara	Pahadi, Kumher	1800	16.67	300	600	22.22
2017–18	Nagla Sawai Ram, Baben, Maharawar, Luhasa, Songaon, Alamshah, Mahmadpur, Khadraya, Khohra, Satwas	Kumher, Nadbai, Deeg, Nagar, Weir, Bayana, Kaman,	1946	17.42	339	415	15.37
2018–19	Badangarh, Nagla Manjhi, Kanchanpura, Rundh Ikaran, Pana, Eklehra	Deeg, Kumher, Bharatpur, Roopwas, Pahadi	2179	20.19	440	81	3.00
2019–20	Borai, Ajaypura, Jarhara, Nangla Baghera, Bhatpura, Kheda Karoli, Janoothar, Khohra, Goojar Balai, Padalwas	Kumher, Deeg, Bayana, Roopwas, Nagar	1160	15.68	182	1358	50.30
2020–21	Badangarh, Kanchanpura, Ajaypura, Sikrori, Maharawar, Bansi Kalan, Satwas, Moroli Khurd	Deeg, Kumher, Sewar, Kaman, Bharatpur	1872	20.19	378	450	16.67
2021–22	Borai, Sabora	Kumher	1686	18.03	304	710	26.30
Mean	-	-	1774	18.26	323.83	602.33	22.31
Total	-	-	-	-	-	-	-

Demo: Demonstration, H: Highest, L: Lowest, Av: Average, FP: Farmer's practice, EG: Extension gap, Technology gap, TI: Technology index average yield from farmer's practices was 17.74 q ha^{-1}. Under improved technology 15.68 to 20.19% increase in yield over the farmer's practice were recorded. Thus, there was on an average 18.26% increase in demonstration yield over farmer's practice during six years of demonstrations. Demonstrated mustard variety DRMRIJ-31 gave the highest seed yield (26.19 q ha^{-1}) during year of 2018–19. The results clearly indicate that the increase in yield in demonstration over farmer's practice was the impact of improved production technology of mustard cultivation over the existing farmer's practices toward enhancing the yield of mustard in different clusters of Bharatpur district. Parashar et al. (2022) showed that the yield of mustard increased from 23.83 to 28.97% over farmer's practice during the demonstration period from 2018–19 to 2020–21. Fluctuations in yield observed during the study years were mainly on account of variation in soil condition, its fertility levels, rainfall pattern, sowing time and crop management practices (Leharwan et al., 2023).

3.3. Adoption gap

Data (Table 2) revealed that adoption gap was considered a key factor for enhancing the productivity of mustard. Gap analysis was done by evaluating the extension gap, technology gap and technology index to measure the magnitude of adoption technology.

3.4. Technology gap

The data of table 2 depicted the technology gap in demonstration's yield against potential yield which varied from 81 to 1358 kg ha^{-1} during different years of demonstration with a mean technology yield gap recorded at 602.33 kg ha^{-1}. Technology gap was maximum (1358 kg ha^{-1}) during 2019–20 and minimum (81 kg ha^{-1}) during 2018–19. The mean technology gap during six years of demonstrations were 602.33 kg ha^{-1} for mustard cultivation in Bharatpur district. The results of present study were in conformity with the finding of Shivran et al. (2020) who reported technology yield gap ranging from 157–1374 kg ha^{-1} with an average technology yield gap recorded at 655 kg ha^{-1} during all the years of study. The technology gap observed might be attributed to dissimilarity in crop management practices and variation in soil fertility and local agro-climatic situations (Sharma et al., 2024; Kumar and Jakhar, 2022). It indicated the constraints in implementation of technology and drawbacks in our package of practices. This also reflected the poor extension activities, which resulted in reduced adoption of package of practice by the partner farmers (Leharwan et al., 2023).

3.5. Extension gap

Extension gap was considered a parameter to know the yield difference between the demonstrated improved technology and farmer's practices. The results of the demonstrations (Table 2) specified that the extension gap fluctuating from 182 to 440 kg ha^{-1} during period of study. The extension gap was highest (440 kg ha^{-1}) and lowest (182 kg ha^{-1}) during the year 2018–19 and 2019–20, respectively. The mean extension gap during study period was 323.83 kg ha^{-1} for mustard cultivation in Bharatpur district. So, there was need to minimise the wider extension gap to enhance the farmer's income (Shivran et al., 2020; Leharwan et al., 2023). It was also needed to educate the farmers through various means for adoption of improved production technologies (Hooda and Jangra, 2024; Meshram et al., 2022; Kumar et al., 2019) or recommended production technologies (Kumari and Singh, 2022)/latest agro-technologies (Shivran et al., 2020) to reduce the extension gap. Similarly, the extension yield gap ranging from 200–600 kg ha^{-1} with an average extension yield gap of 443 kg ha^{-1} during all the years of demonstrations has also been reported by Shivran et al. (2020).

3.6. Technology index

The technology index was a parameter to display the feasibility of the improved technology at the farmer's fields. The lower value of technology index showed more was the feasibility of improved technology and higher technology index reflected the inadequate transfer of demonstrated technology to cultivators and poor extension services. Data on technology index presented in table 2 displayed that technology index ranged from 3.00 to 50.30%. During study period of front line demonstrations, the highest technology index (50.30%) and lowest (3.00%) was reported during year of 2019–20 and 2018–19, respectively. The mean technology index during six experimental years of mustard cultivation in Bharatpur district was 22.31%, which displayed the efficacy of good performance of technical interventions. While working at Karnal on mustard Leharwan et al. (2023) also reported technology index of 20.00 to 57.11% with an overall average of 36.85% during five experimental years. This would accelerate the adoption of demonstrated technical interventions to increase the performance of mustard yield at farmer's field (Leharwan et al., 2023; Singh et al., 2023; Kumar and Jakhar, 2022). The technology index concluded that there was plentiful scope in improvement in production and productivity of mustard in the district.

3.7. Economics

Economics was an important parameter to accept or reject the technology under the investigations. Seed yield, cost of variable inputs, labour charges and sale price of the product determined the economic return, and these varied from year to year. Under front line demonstrations, economics of improved technology was estimated (Table 3). Based on prevailing market rates recorded, the higher gross monetary return (₹ 109998 ha^{-1}) and additional returns (₹ 18480 ha^{-1})

were observed with improved technology demonstration compared to farmer's practice during the year 2018–19. The higher net returns (₹ 85427 ha^{-1}), effective gain (₹ 15030 ha^{-1}) and B:C ratio (4.47) were recorded with improved technology demonstration compared to farmer's practice during the year 2018–19. The present investigation showed that improved technology fetched higher net return to the tune of ₹ 38084 to ₹ 85427 ha^{-1} with the mean of six years (₹ 65064 ha^{-1}). However, under farmer's practice the net return ranged from ₹ 32105 to ₹ 70397 ha^{-1} over the years and its mean value fetched to ₹ 53760 ha^{-1}. Further, the mean of all six years of study revealed that improved technology demonstration gave higher gross return (₹ 90250 ha^{-1}), additional returns (₹ 13970 ha^{-1}), net return (Rs. 65064 ha^{-1}), effective gain (₹ 11305 ha^{-1}) and benefit: cost ratio (3.57) compared to farmer's practice. Leharwan et al. (2023) also reported higher average net profitability under front-line demonstrations (₹ 53709 ha^{-1}) compared to the farmer's practices (₹ 37527 ha^{-1}) and average benefit: cost ratio i.e., 3.13 and 2.58 in demonstrated field and farmer's practice, respectively. The benefit: cost ratio (BCR) of 4.14 was recorded by Kumari and Singh (2022) in demonstrated plots which were significantly higher than check plot (2.70). Meena et al. (2022) also fetched higher net returns to the tune of ₹ 32935 to ₹ 53609 ha^{-1} under front-line demonstrations, however, under farmer's practices the net returns ranged to the tune of ₹ 26402 ha^{-1} to ₹ 39730 ha^{-1} over the years. Meshram et al. (2022) recorded average higher B:C ratio (3.31) under front line demonstrations due to adoption of improved package of practices as compared to farmers practice (2.79) during the period of study. Shivran et al. (2020) also reported enhanced average gross (₹ 76,318 ha^{-1}), net return (₹ 50,740 ha^{-1}), effective gain (₹ 12,393 ha^{-1}) and additional return (₹ 14,107 ha^{-1}) with higher benefit: cost ratio (2.95) in comparison to farmer's practice (2.50) during six year's study period. The higher effective gain and additional returns gained under front line demonstrations could be due to improved technological interventions and non-financial factors, timely operations of crop management practices and scientific monitoring during the crop period. Further, favourable benefit cost ratio obtained under improved technological intervention under specific agro-ecological situation proved the economic viability of the technological intervention and convinced the farmers on utility of interventions.

Table 3: Economics of the cluster front line demonstrations on mustard

Year	Cost of cultivation (₹ ha^{-1})		Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})		% increase in net return	Additional cost (₹ ha^{-1})	Additional return (₹ ha^{-1})	Effective gain (₹ ha^{-1})	Benefit-cost ratio	
	Demo.	FP	Demo.	FP	Demo.	FP					Demo.	FP
2016–17	24585	22275	75600	64800	51015	42525	19.96	2310	10800	8490	3.07	2.90
2017–18	25250	22200	91400	77840	66150	55640	18.89	3050	13560	10510	3.61	3.50
2018–19	24571	21121	109998	91518	85427	70397	21.35	3450	18480	15030	4.47	4.33
2019–20	21300	19225	59384	51330	38084	32105	18.62	2075	8054	5979	2.78	2.66
2020–21	30811	27411	104625	87048	73814	59637	23.77	3400	17577	14177	3.39	3.17
2021–22	24600	22890	100495	85143	75895	62253	21.91	1710	15352	13642	4.08	3.71
Mean	25186	22520	90250	76280	65064	53760	20.75	2666	13970	11305	3.57	3.38

Demo: Demonstration, FP:Farmer's practice; 1US$=65.86, 65.03, 69.58, 74.52, 72.77 and 76.23 INR (average value of March, 2017, March, 2018, March, 2019, March, 2020, March, 2021 and March, 2022, respectively)

4. CONCLUSION

Adoption of improved production technologies/ latest agro-technologies through frontline demonstrations had a long-term impact on productivity, profitability and sustainability of mustard and changing the knowledge, attitude and skills of farmers. The mustard variety DRMRIJ-31 performed better in respect to seed yield, return and benefit-cost ratio in Bharatpur district (Flood Prone Eastern Plain Zone-IIIB of Rajasthan).

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