Biological Forum – An International Journal **15(12): 167-173(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Promotion of Indian Mustard through Cluster Front Line demonstrations in the Eastern-Gangetic Plains of India

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(Received: 16 October 2023; Revised: 02 November 2023; Accepted: 19 November 2023; Published: 15 December 2023)
(Published by Research Trend)

ABSTRACT: On-farm cluster front-line demonstrations (CFLDs) were conducted during *rabi* season for eight consecutive years (2015-16 to 2022-23) in Bihar to demonstrate the impact and production potential of improved technologies. The CFLDs were conducted by Krishi Vigyan Kendra, Bhagalpur, Bihar, on the mustard crop in Bhagalpur districts of Bihar to know the yield gap, technology gap, extension gap, economic return, extent of farmer's satisfaction, and constraints faced by the farmers, especially mustard growers. The results revealed that the average highest seed yield (15.81 q/ha) of mustard was recorded under the improved scientific production technology of CFLD, which consists of high-yielding varieties (RGN 48, Rajendra Sufalam, and RH 725), seed treatment, timely sowing, nutrient management with sulfur application, management of insect pests, diseases, and weed flora. Whereas, an average existing farmer's practice produced only 11.80 q/ha seed yield of mustard. The highest extension gap (6.10 q/ha) was recorded during 2018–19, whereas the mean extension gap during eight years was 4.01 q/ha. The highest technological gap (11.86 q/ha) and technology index (44.9%) were registered for RGN-48 during 2019–20, and the lowest technology gap (0.47 q/ha) and technology index (3.90%) were recorded for Rajendra Sufalam during 2015–16. Average of 948 farmers plots performance of eight years, demonstration plots under CFLD also obtained higher net return (₹ 43945/ha) and benefit cost ratio of 2.89 as compared to existing farmers practice.

Keywords: CFLD, Economics, Gap, Mustard and Yield.

INTRODUCTION

Indian mustard (*Brassica juncea* L.) is one of the most important winter oilseed crops of India, occupies a prominent place among oilseed crop being next to groundnut with 93.40 lakh tonnes production from 62.30 lakh ha, with a productivity of 14.99 q/ha (Anonymous, 2020). Whereas, 10.39 q/ha productivity of mustard was noticed in Bhagalpur district as compare to 11.25 q/ha of Bihar state in 2021-22. Mustard gives edible oil and generally used as cooking. Its seed is most often used as spice in the preparation of vegetable, curries and pickles. Mustard tender succulents green leaves are also used as green vegetables which supplies sulphur and minerals in the diet and its oilcake is used as animal feed and manure. Mustard is a good source of income for poor farmers particularly under rainfed conditions, (Sangwan *et al*., 2021). India has 27.14 mha area of oilseed crops with the production of 33.22 m t and productivity of 12.24 q/ha with seconds and third position of rapeseed mustard in area and production in world, respectively (DES, 2019-20). India became independence in oilseeds during the first half of the 1990's but could not sustain the same during the present millennium owing to a platter of market and non-market forces. Mustard crop productivity in Bhagalpur district is low as compared to its state and national level mainly due to abiotic (drought, flood, temperature variation, and salinity) and biotic (disease and insect) stresses, a lack of proper nutrient management practices, weed management, intercultural operations, seed treatment, poor crop management practices, inadequate availability of quality seed of improved mustard varieties, inadequate plant protection measure, small and marginal holding, and other inputs, as well as poor knowledge about the scientific production of mustard crop.

In order to promote high-yielding mustard varieties, cluster frontline demonstrations (CFLDs) were implemented in 2015–16. These demonstrations included seed treatment, biofertilizer application, integrated nutrient management with sulfur involvement, integrated pest disease management, line sowing, weed management, irrigation management, and extension activities such as training, field days, and mass media campaigns, all carried out under the close supervision of scientists. For research purposes, KVK scientists generate production data and feedback information in the CFLD program by analyzing factors that contribute to higher crop production as well as field constraints of production. Consequently, CFLD is a useful technique for demonstrating technological intervention on farmers' fields in order to maximize the potential yield of technology. Aiming to assess and analyze the effects of technology interventions on mustard yield and economics in the Bihar district of Bhagalpur, the current CFLD investigation was designed with this goal in mind.

MATERIALS AND METHODS

The present investigation of CFLD on the mustard crop was conducted for eight consecutive years in the *Rabi* season from 2015-16 to 2022-23 in irrigated conditions by KVK Sabour, Bhagalpur, at 440 ha with the active participation of 948 farmers in 41 villages under 10 blocks of Bhagalpur, Bihar Table 1. An average of all sites, the soil was silty loam to clay loam in texture, with soil pH 7.23, EC 0.28 dS/m, low in organic carbon (0.53%), low in available nitrogen (224.8 kg/ha), medium in available P_2O_5 (22.62 kg/ha), and medium in available K_2O (259.38 kg/ha). On an average the climate of the district is hot and humid at lower altitudes and cold at upper altitudes. A list of Interested farmers was prepared before conducting demonstration through group meetings, discussion, and specific skill training. Various landholding size farmers *i.e.*, large, medium, and small, were participated in CFLD. Adjoining each cluster demonstration plot was kept at least one existing farmer's practices or control plot, where existing farmer's practice was followed.

Demonstrations were conducted in an integrated crop management manner on the basis of identified causes for low yield, as suggested by Choudhary (1999); Venkatta Kumar *et al.* (2010). Critical inputs for technological intervention like seed (Rajendra Sufalam, RGN-48, and RH-725), carbendazim, chloropyriphos, PSB culture, Sulfur, yellow stick card, imidaclorpid, Mancozeb 64% WP + Metalaxyl 8% WP were provided by KVK to selected farmers, and the remaining other inputs were arranged themselves by farmers.All the demonstrations were followed as per the recommended package and practices. Organized training on various aspects of mustard production for selected farmers and local extension functionaries at the village level/KVK center before conducting demonstrations. Subsequently, KVK scientists visited demo plots at various crop growth stages to ensure proper guidance to the farmers and extension functionaries. Field day was organized at the demonstrated plot on the crop maturity stage with the active participation of beneficiaries and non-beneficiaries farmers of the village or adjoining village and local extension functionaries to show the superiority of the technology and disseminate the message on a large scale. The crops were harvested in the third week of February to second week of March after maturity.

The yield data were collected from both the demonstration and existing farmers practices (control plot) by random crop cutting methods and analyzed using suitable statistical tools. For the calculation of yield, cost of cultivation, gross returns, net returns, and the B:C ratio, mean values were taken from selected farmers. The analysis of the extension gap, technology gap, and technology index led to the drawing of final conclusions (Samui *et al*., 2000). The following analysis tools are used for assessing the performance of the FLDs on the mustard crop:

— Extension gap (q/ha) = Demonstration yield – Farmer's practice yield

$$\text{Yield gap (\%)} = \frac{\text{Demontartion yield} - \text{Control yield}}{\text{Control yield}} \times 100$$

— Technology gap (q/ha) = Potential yield – Demonstration yield

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

— Additional cost (₹) = Demonstration cost (₹/ha) – Farmer's practice cost (₹/ha)

—Additional returns (₹) = Demonstration returns (₹/ha)–Farmer's practice returns (₹/ha)

—Effective gain (₹) = Additional returns (₹/ha) – Additional cost (₹/ha)

—Incremental B: C ratio = Additional returns (₹/ha) ÷ Additional cost (₹/ha)

RESULTS AND DISCUSSION

A. Technology intervention

The comparison of the technology gap between frontline demonstrations (FLDs) and existing farmer's practices (FP) at villages is presented in Table 2. Farmers of adopted villages were using local and old/outdated varieties; late sowing, high seed rate, no seed treatment, low/imbalance fertilizer rate without sulfur application, no weeding, and no insect pest and disease management were common practices. According to the information collected from the demonstrated village, there was a complete gap in the use of HYVs, seed treatment, seed rate, fertilizer dose, weed control, insect-pest management, disease management, technical guidance provided to the farmers, and harvesting and threshing. However, there was a partial gap observed in the sowing times, sowing in residual soil moisture, and water management. No gap was observed with respect to field/land preparation. The farmers in the adopted village were not very familiar with the recommended mustard crop production techniques. The low yield potential of the mustard crop in the demonstration village and the surrounding area was primarily due to these gaps in improved technology.

B. Yield performance

The yield data of the mustard crop obtained during eight years of FLD is presented in Table 3. Data of eight years from a 440 ha area with the active participation of 948 farmers revealed that the mustard seed yield ranged from 11.53 to 19.30 q/ha in demonstration practice under the CFLDs program, with an average seed yield of 15.81 q/ha as compared to 9.88 to 13.20 q/ha in existing farmers' practices, with an average yield of 11.80 q/ha (control plot). The seed yield of mustard in demo practice increased from 16.7 to 46.2% from existing farmers practice, with an average of 33.4%. The data on the demo technique in the CFLDs program motivated the farmers, and farmers agreed to use improved scientific production techniques in the future. It might be due to proper management of nutrients, water, time, weed flora, insect pests, and diseases in high-yielding varieties of mustard as compared to existing farmer practices. The results of CFLDs clearly show the positive effects of enhancing the seed yield over the existing farmer's practices. There was year-to-year variety ear in the average yield of mustard, which varied from 11.53–19.30 q/ha in the case of improved practices and 9.88–13.20 q/ha in farmers practices. The results also revealed that the average seed yield of mustard in CFLDs and existing farmers practices was higher than state and district yields. Similar findings in various crops were also reported by Mauriya *et al.* (2017); Kushawaha *et al.* (2016); Kumar and Jakhar (2020); Hashim *et al.* (2022); Hashim *et al.* (2023).

C. Yield gaps (Extension gap and technology gap)

In my investigation, the technological gaps and extension gaps were calculated. The term "extension gap" describes the difference between the yield that has been demonstrated and the yield that farmers are currently practicing. Similarly, "technological yield" refers to the difference between the yield that a variety has the potential to produce and the yield that has been demonstrated at farmers' fields under the guidance of scientists. An average 4.01 q/ha extension gap and 8.74 q/ha technology gap were calculated in the present study (Table 3). Results showed that the highest extension gap (6.10 q/ha) was recorded during 2018–19, whereas the minimum extension gap (1.65 q/ha) was recorded during 2015–16, and the mean extension gap during eight years was 4.01 q/ha. The highest technological gap (11.86 q/ha) was registered for RGN-48 during 2019–20, and the lowest technology gap was recorded for Rajendra Sufalam during 2015–16 (0.47 q/ha), while the overall mean technological gap was 8.74 q/ha. The lower technological gap recorded in 2015–16 indicates that the lower technological gap has an inverse relationship with crop yield, as a narrower gap resulted in more adoption of the demonstrated technology. The technological gap may be due to variations in soil fertility, agroclimatic conditions, integrated crop management practices, the skills of farmers, and other agronomical practices. Therefore, site-specific recommendations should be generated to fill these gaps. However, the extension gap indicates that there is a need to educate farmers and provide training and awareness programs to encourage the early adoption of improved agricultural production technologies. Farmers will eventually be convinced to abandon the old practices and adopt the new ones by this new technology. These findings were close to those of Shivran *et al.* (2020); Hashim *et al.* (2022); Hashim *et al.* (2023) in different crops.

D. Technology index

The data presented in Table 3 revealed that the technology index varies from 3.9% to 44.9%, with an average of 33.5% in our study. The technology index indicated the feasibility of newly developed production technology at farmers fields in existing climatic conditions. The overall mean technological index was 33.5%, which may be due to variations in soil fertility status, uneven and erratic rainfall, and the weather conditions of the area. The lower value of the technology index shows more feasibility and applicability of the newly recommended technology. A higher technology index indicates the inadequacy of technology and/or insufficient extension services for technology transfer. The technology index shows that there is sufficient scope for improvement in the production and productivity of mustard in these areas. This finding is in corroboration with the findings of Mauriya *et al.* (2019); Hashim *et al.* (2022); Hashim *et al.* (2023); Jha *et al.* (2021).

E. Economic analysis

Economics is a very important parameter that shows the technology's acceptance or rejection by the farming community. The economic evaluation was made on the basis of the prevailing market prices of inputs and outputs. On the basis of an average of eight years from 2015–16 to 2022–23, it was revealed that the highest net return (₹ 43945/ha) was reported under the demonstration plot of CFLD, which was 46.3% higher than existing farmers practices (Table 4 & 5). The highest benefit-cost ratio (2.89) was also noted in improved technology demonstrations in CFLDs. The demonstration of mustard conducted over a period of eight consecutive years gave an average effective gain of ₹ 13911/ha, with the addition of an additional cost of ₹ 4214/ha. The incremental benefit-cost ratio (5.84) is sufficiently high to motivate the farmers to adopt the technology. This finding is in concordance with the findings of Kumar and Mauriya (2014); Balai *et al.* (2021); Hashim *et al.* (2022); Hashim *et al.* (2023).

F. Feedback of the farmers and extent of farmer's satisfaction

New varieties and technologies were eagerly embraced by the farmers in the adopted village. The improved variety was a proven benefit over the older technologies. The majority of farmers believe that if input support is stopped, they will adopt proven technologies. The level of satisfaction with the support provided was also satisfactory (Table 5). The extent of farmer satisfaction with front-line demonstrations presented in Table 6 showed that the majority of the respondent farmers expressed a high (86%) and medium (9%) level of satisfaction regarding the performance of FLDs, whereas very few (5%) of respondents expressed a lower level of satisfaction. Increased adoption is predicted as a result of this stronger conviction and increased mental and physical participation in the cluster front-line demonstrations.

Table 1: The geo-tagging of selected villages of CFLD.

Year	Village	Block	Latitude	Longitude
2015-16	Barhari	Goradih	25^{0}14.388′	087^{0}02.893′
	Birnaudh	Goradih	25^{0}09.998′	087^{0}03.271′
	Pakra	Naugachhiya	25^{0}21.900′	087^{0}04.978′
	Disharath	Sanahaula	25^{0}09.073′	087^{0}09.978′
	Ghanshyamchak	Sanahaula	25^{0}08.058′	087^{0}10.276′
	Maalpur	Gopalpur	25^{0}34.173′	087^{0}11.924′
	Mohanpur	Shahkund	25^{0}06.572′	087^{0}54.445′
	Awa Mokhtarpur	Sultanganj	25°08.508′	086°45.650′
2016-17	Ganga Prasad	Nathnagar	25°12.722′	086°54.121′
	Phulwariya	Sanhaula	25°07.992′	086°16.679′
	BhatthaChak	Shahkund	25°09.024′	086°48.090′
	Basantpur	Sultanganj	25°14.702′	086°50.514′
	KalyanpurBhuska	Kahalgaon	25°13.562′	087°17.145′
	Kharwa	Goradih	25°09.418′	087°05.376′
	Barhari	Goradih	25°07.519′	087°03.150′
	Birnaudh	Goradih	25°07.926′	087°03.792′
	Awa Mokhtarpur	Sultanganj	25°08.428′	086°45.811′
	Tarchha	Goradih	25°06.190′	087°05.791′
2017-18	Kirtanya	Pirpaiti	25^{0}14.992′	087^{0}28.192′
	Akabarpur	Kahalgaon	25^{0}14.368′	087^{0}19.360′
	Tarar	Sanahaula	25^{0}11.169′	087^{0}10.630′
2018-19	Judabanpur	Pirpaiti	25^{0}14.820′	087^{0}25.165′
	Sonudih	Sanhaula	25^{0}10.336′	087^{0}09.373′
	Gangarampur	Sanhaula	25^{0}08.439′	087^{0}15.193′
	Belsira	Nathnagar	25^{0}14.570′	086^{0}92.914′
2019-20	Tilakpur	Sultanganj	25^{0}15.043′	086^{0}47.326′
	Harla	Pirpainti	25^{0}13.386′	087^{0}28.045′
	Manikpur	Pirpainti	25^{0}21.308′	087^{0}45.234′
	Jagannathpur	Pirpainti	25^{0}18.223′	087^{0}33.176′
	Kangalichauki	Pirpainti	25^{0}15.487′	087^{0}29.159′
	Phulwariya	Sanhaula	25^{0}07.257′	087^{0}16.830′
	Awa Mukhatarpur	Sultanganj	25^{0}08.123′	086^{0}45.390′
	Fatehpur	Sultanganj	25^{0}13.457′	086^{0}40.148′
	Kamarganj	Sultanganj	25^{0}14.017′	087^{0}40.793′
	Shree Rampur	Sultanganj	25^{0}13.550′	086^{0}50.263′
	Akabarnagar	Sultanganj	25^{0}13.620′	086^{0}50.234′
	Chaturchak (Uradih)	Sultanganj	25^{0}20.883′	086^{0}73.535′
2020-21	Mirhatthi	Sultanganj	25^{0}23.667′	086^{0}76.261′
	Kolagama	Sultanganj	25^{0}24.620′	086^{0}76.8895′
	Tilakpur	Sultanganj	25^{0}15041′	086^{0}47.329′
	Jahangira	Sultanganj	25^{0}23887′	086^{0}68.9917′
	Fatehpur	Sultanganj	25^{0}13.457′	086^{0}40.148′
	Kamarganj	Sultanganj	25^{0}14.017′	087^{0}40.793′
	Awa Ratanpur	Sultanganj	25^{0}14.43′	086^{0}763858′
	Tarar	Sanhaula	25^{0}17.83′	087^{0}16.5603′
2021-22	Babhangama	Kahalgaon	25^{0}28.6735′	087^{0}27.7605′
	Habbipur	Kahalgaon	25^{0}31.2538′	087^{0}32.1846′
	Laugay	Kahalgaon	25^{0}30.7563′	087^{0}31.7211′
	Tamauni	Nathnagar	25^{0}16.9793′	086^{0}93.2604′
	Kajraili	Nathnagar	25^{0}16.902′	086^{0}91.274′
2022-23	Rajpur	Sabour	25^{0}22.0842′	087^{0}06.5326′
	Harla	Pirpainti	25^{0}13.386′	087^{0}28.045′
	Tamauni	Nathnagar	25^{0}16^{1}9793′	086.93.2604′

Table 2: Technology intervention in CFLD and existing farmers' practices.

Sr. No.	Intervention	Technology intervention in CFLD	Existing farmer's practice	Gap
1.	Variety	Rajendra Sufalam, RGN-48 and RH-725	Old and local varieties	Full gap
2.	Seed treatment	Seed treatment with Carbendazim 50 WP @ 2.5 g/kg seed, Chloropyriphos 20% EC @ 8.0 ml/kg seed, and PSB culture @ 20 g or 5 ml/kg seed	Without seed treatment	Full gap
3.	Land preparation	Three times ploughing with cultivator followed by planking	As in case of CFLD	Nil
4.	Sowing time	As per recommendation (Second fortnight of October to first fortnight of November)	Sowing partially delay (First week of November to last week of November)	Partial gap
5.	Sowing in residual moisture	Yes	Yes/no	Partial gap
6.	Seed rate	5 kg/ha	7-8 kg/ha or more	Full gap
7.	Nutrient management	Balance dose of fertilizers in INM manner with 25 kg sulphur applied as basal	Imbalance dose of fertilizer without sulphur application	Full gap
8.	Weed control	Pendimethalin @ 1.0 kg a.i./ha applied as pre-emergence	No weeding	Full gap
9.	Water management	Two light irrigation as per weather condition (first at 20-25 DAS and second at pre flowering) with proper drainage	1-2 irrigation without follow of suitable method and time	Partial gap
10.	Insect-pest management	Yellow stick card @ 20 pcs/ha and Imidaclorpid 17.8% SL @ 500 ml/ha (insecticide as per need)	No chemical control measures followed	Full gap
11.	Diseases management	Mancozeb 64% WP + Metalaxyl 8% WP application @ 0.6 kg/ha (as per need)	No chemical control measures followed	Full gap
12.	Technical guidance	Time to time	Nil	Full gap
13.	Harvesting and threshing	Harvesting and threshing at the right time	No timely harvesting and threshing was done	Full

Table 3: Impact of improved technologies under CFLDs on yield and yield gap of mustard.

Year	Varieties under CFLDs	Area under Demo. (ha)	No of demonstrations/farmers	Farmer's practice yield (Average yield q/ha)	Demo. yield (q/ha)	District yield (q/ha)	State yield (q/ha)	Potential yield (q/ha)	Yield gap minimized (%)			% yield increase over FP	Ext. gap (q/ha)	Tech. gap (q/ha)	Technological index (%)
									Dist.	State	Potential				
2015-16	Rajendra Sufalam	20	70	9.88	11.53	10.17	10.81	12.00	11.80	6.24	3.92	16.7	1.65	0.47	3.9
2016-17	RGN-48	30	60	12.60	17.40	10.74	11.00	26.39	38.28	36.78	34.07	38.1	4.80	8.99	34.1
2017-18	RGN-48	30	80	11.80	15.70	10.81	11.80	26.39	31.15	24.84	40.51	33.1	3.90	10.69	40.5
2018-19	RGN-48	30	46	13.20	19.30	11.23	12.90	26.39	41.81	33.16	26.87	46.2	6.10	7.09	26.9
2019-20	RGN- 48	150	280	10.76	14.53	12.97	11.87	26.39	10.74	18.31	44.94	35.0	3.77	11.86	44.9
2020-21	RGN- 48	120	256	11.61	15.46	11.64	12.71	26.39	24.71	17.79	41.42	33.2	3.85	10.93	41.4
2021-22	RGN- 48	40	106	12.87	17.00	10.39	11.25	26.39	38.88	33.82	35.58	32.1	4.13	9.39	35.6
2022-23	RH-725	20	50	11.67	15.52	10.31	11.18	26.00	33.57	27.96	40.31	33.0	3.85	10.48	40.3
Total/mean		440	948	11.80	15.81	11.03	11.69	24.54	28.87	24.86	33.45	33.4	4.01	8.74	33.5

Table 4: Impact of improved technologies under CFLDs on economics of mustard.

Year	Variety	Farmer's practice			Demonstration plot			Additional cost (₹/ha)	Additional net returns (₹/ha)	Additional gain (₹)	% increase in net return	Incremental B: C ratio
		Cost of cultivation (₹/ha)	Net Return (₹/ha)	B:C ratio	Cost of cultivation (₹/ha)	Net Return (₹/ha)	B:C ratio					
2015-16	Rajendra Sufalam	18200	20844	2.14	19450	25864	2.33	1250	5020	3770	24.1	4.02
2016-17	RGN-48	19850	29350	2.48	25790	41635	3.61	5940	12285	6345	41.9	2.07
2017-18	RGN-48	19555	18312	1.94	25931	32180	2.30	6376	13868	7492	75.7	2.18
2018-19	RGN-48	19965	26495	2.33	26223	41642	2.59	6258	15152	8894	57.2	2.42
2019-20	RGN-48	21234	21011	1.99	26455	29648	2.12	5221	8637	3416	41.1	1.65
2020-21	RGN-48	21343	48073	3.24	26459	66268	3.50	5116	18195	13079	37.8	3.56
2021-22	RGN-48	22056	43671	2.98	24354	64573	3.68	2298	20902	18604	47.9	9.10
2022-23	RH-725	23490	32526	2.38	24745	49751	3.01	1255	17225	15970	53.0	13.73
Mean		20712	30035	2.44	24926	43945	2.89	4214	13911	9696.3	46.3	4.84

Table 5: Comparative economics of mustard improved technology and farmer's practices.

Particulars	Farmer's practice	Improved technology	Actual increase over farmer's practice	Increase over farmer's practice (%)
Average yield (q/ha)	11.80	15.81	4.01	34.00
Cost of cultivation (₹/ha)	20712	24926	4214	20.34
Net return (₹/ha)	30035	43945	13910	46.31
B: C ratio	2.44	2.89	0.45	18.44

Table 6: Feedback of the farmers.

Particulars	Feedback
Benefits of the demonstrated variety in comparison to local check	Beneficial
Response of the neighbouring farmers to the FLDs	Positive
Level of satisfaction with yield	Very high
Will the farmer adopt the demonstrated technologies if input support is discontinued	Yes
Level of satisfaction with the support provided	Satisfactorily

Table 7: Extent of Farmer's Satisfaction about Front Line Demonstration (N= 100).

Satisfaction Level	Frequency	Percentage
Low	5	5
Medium	9	9
High	86	86

CONCLUSIONS

Farmers and scientists had a better relationship as a result of Cluster Frontline Demonstrations (CFLDs). The CFLDs demonstration farmers served as the main source of information regarding the more advanced methods of mustard cultivation. They served as a source of pure, high-quality seeds for the following crop in their community and the surrounding area. The farmers' financial problems and standard of living will improve as a result of the CFLDs' significant reduction of the extension and yield gap. On the basis of eight-year investigation, it may be concluded that improved scientific production technology for mustard in CFLD is more productive and profitable as compared to existing farmers practices through organizing and conducting training, group discussions, farmer's visits, field days, campaigns, and demonstrations.

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How to cite this article: A.K. Mauriya, Mohammad Hashim, Pankaj Kumar, Mamta Kumari, Raghubar Sahu, R.K. Verma and V. K. Maurya (2023). Promotion of Indian Mustard through Cluster Front Line demonstrations in the Eastern-Gangetic Plains of India. *Biological Forum – An International Journal, 15*(12): 167-173.