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Gap Analysis and Economic Viability of Front-line Demonstrations in Indian Mustard (*Brassica juncea* L.) under Hyper Arid Partial Irrigated Zone of Rajasthan

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Abstract

Performance analysis in terms of gap analysis, yield enhancement and economic viability of improved production technologies of Indian mustard vis-à-vis farmers' practice was evaluated through front-line demonstrations at farmers' field during *rabi* seasons (October to March) of respective years, 2013-2014 to 2018-2019. The front-line demonstrations were conducted by Krishi Vigyan Kendra, Bikaner-II, Rajasthan. Newly released improved varieties of Indian mustard viz., RGN 48, RGN 229 and DRMRIJ 31 were grown under demonstrations. The experimental results envisage that average yield under demonstration ranged from 1550 to 2600 kg ha^{-1} with a mean of 2154 kg ha^{-1}. In per cent terms, scaling in productivity following improved technology ranged from 14.81 to 33.33% with an average value of 25.89% (over the Farmers' practice). Moreover, the grain yield also recorded substantially higher under demonstrations (2154 kg ha^{-1}) over district average (1122 kg ha^{-1}) and state average (1427 kg ha^{-1}). The average yield gaps for technology, extension and technology index were 655, 443 kg ha^{-1} and 22.90 per cent, respectively. Demonstration of improved technologies also 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}) in comparison to Farmers' practice. This resulted in realizing higher incremental cost benefit ratio (8.23) and benefit: cost ratio (2.95) compared to the Farmers' practice (2.50) during six years study period. This enhancement in grain yield and economics of chickpea under demonstrations clearly showed the impact of adoption of improved technology over farmers' practice in Hyper Arid Partial Irrigated Plain Zone of Rajasthan.

Keywords: Economics, Front-line demonstrations, Indian mustard, technology index, yield gap

1. Introduction

Oilseed crops occupy a significant place in the Indian economy, next to food grains. Rapeseed-mustard is the third important oilseed crop grown in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) oil. The area, production and yield of rapeseed-mustard in the world was 36.68 mha, 72.42 mt and 1974 kg ha^{-1}, respectively, during 2017-18. Globally, India accounts for 19.8 % and 9.8% of the total acreage and production (Anonymous, 2019). India is an important rapeseed-mustard growing country in the world, occupying the third position in its production after Canada and China. Of the seven edible oilseeds cultivated in India, contribution of rapeseed-mustard (*Brassica* spp.) is 28.6% in the total production of oilseeds. In India, it is the second most

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important edible oilseed after soybean which shares 27.8% in the India's oilseed economy (Anonymous, 2020). Of the total cropped area in India, the share of oilseeds is 13.33% in which rapeseed-mustard accounts for more than 3%. In India, rapeseed-mustard grown in 7.92 mha with production of 9.34 mt with average productivity of 1499 kg ha^{-1} (Anonymous, 2019a; 2020). The rapeseed-mustard broadly comprises of Indian mustard, yellow sarson, brown sarson, raya, and toria. In the recent past, the area under Indian mustard is on the increase at the cost of other Brassicas due to its higher productivity and tolerance to biotic and abiotic stresses. Further, rapeseed cultivation is confined only to northern India. It is because of the late maturity and shattering of pods owing to high temperature prevails during harvest in February- March.

Indian mustard (*Brassica juncea* (L.) Czern and Coss) is primarily cultivated in Rajasthan, Uttar Pradesh, Haryana, Gujarat and Madhya Pradesh. Rapeseed-mustard contributes to 32% of the total oilseed production in the country and making it the country's key edible oilseed crop. Indian mustard is one of the most important oilseeds crops of Rajasthan, which is primarily raised for its edible oil. Rajasthan accounts a lion share of 40.69% in rapeseed- mustard production followed by Haryana (13.42%) and Uttar Pradesh (11.96%). In Rajasthan, it is grown in 2.39 mha with production of 3.95 mt and productivity in of 1656 kg ha^{-1} (Anonymous, 2018). In addition to quality enhancement of the produce, the introduction of high-yielding rapeseed-mustard varieties, hybrids and refinement of the improved production and protection technologies have contributed significantly in improving the production and productivity of Rapeseed-Mustard in India. The production and productivity of mustard in this area could be further enhanced (Singh et al., 2019), if proper varieties and recommended agronomic practices are made available to the farmers'. Keeping the above point under consideration, front-line demonstrations has been given proper emphasis on the agronomic practices that should be well thought-out for enhancement in production and productivity of Indian mustard in Rajasthan. There is limited scope for bringing an additional area under oilseeds in India (Choudhary and Suri, 2014). Therefore, increasing the oilseeds productivity is only option to meet the national requirement and which is primarily based on adoption of improved production technologies. Further, a wide regional variation in area, production and productivity of oilseeds is persists in India. Though, few states including Haryana, Madhya Pradesh, Rajasthan and West Bengal revealed increase in oilseed production through area expansion and productivity enhancement. In extension system, 'Believing through Seeing' and 'Learning by Doing' accomplished through demonstrations helps Krishi Vigyan Kendra's (KVK) in the technology integration. For technology dissemination, front-line demonstration is a concept of field demonstration evolved by ICAR during the inception of technology mission on oilseed crops and the main objective of front-line demonstration is to demonstrate latest crop production technologies and its management practices at the farmers' field under different agro- climatic regions and farming situations under supervision of the KVK scientists. The purpose is to have an appropriate technology which may be economically profitable, ecologically sustainable, technically feasible and culturally compatible. The front-line demonstration is a long-term educational activity conducted by the KVK scientists in a systematic manner at farmers' field under close supervision to show the worthiness of technology. Besides this, KVK's are acting as a 'Knowledge and Resource Center' at district level on niche areas of agricultural and allied sectors (Sharma et al., 2017). Therefore, in the state of Rajasthan, there is need to organize large scale FLD programs on oilseed crops for harnessing its potential. It is imperative to assess the effectiveness of front-line demonstrations. In view of the above facts, front-line demonstrations were conducted in four blocks viz; Lunkaransar, Chhatargarh, Khajuwala and Pugal of Bikaner district in Rajasthan with the specific objective to evaluate the gap analysis and economic analysis of the improved technologies through demonstrations versus farmers' practices under real farm situations.

2. Materials and Methods

The study was carried out in operational area of Krishi Vigyan Kendra, Bikaner-II (28.517° N Latitude; 73.759° E Longitude and 195m above mean sea level) which falls under Hyper Arid Partial Irrigated Plain Zone (IC) of Rajasthan. Characteristically, the zone covers an area of 7.70 mha, with average rainfall of 100–350 mm, with mean maximum temperature 48 °C and means minimum temperature 3.0 °C. Under the experimentation, a total of 251 demonstrations were conducted in 110.5 ha area during *rabi* seasons (October to March) of respective years, 2013-2014 to 2018-2019. Selection of farmers were done following due technique of Participatory Rural Appraisal (PRA). These demonstrations were carried out under the supervision of KVK scientists. The selection of cultivators was done on the basis of Participatory Rural Appraisal (PRA). Recommended technologies for the agro-climatic zone (Hyper Arid Partial Irrigated Plain Zone, numerated as IC) developed by the university were adopted in letter and spirit for raising Indian mustard. Soils from each demonstration were collected and analyzed for pH, EC, OC (%), available N, available P_2O_5 and available K_2O. Among all demonstrations, the soil texture was sandy loam. However, the soil of demonstration site was low in organic carbon (0.18–0.34%), low in available N (145–185 kg ha^{-1}), medium in available P_2O_5 (16.50–21.40 kg ha^{-1}) and high in available K_2O (285–420 kg ha^{-1}). The soil of the demonstration field was slightly alkaline in soil pH (7.63–8.41) and non-saline to slightly saline in EC (0.85-2.67dS m^{-1}). The improved technology in the front-line demonstration includes introduction of newly released improved varieties of Indian mustard, recommended package and practice including maintenance of optimum plant population and plant protection measures etc (Table 1). Sowing of the

Table 1: Comparison between technology interventions and farmers' practices under front-line demonstration of Indian mustard in Bikaner district of Rajasthan

Sl. No.	Particulars	Technology interventions	Farmers' Practice	Gap
1.	Farming situation	Irrigated	Irrigated	Nil
2.	Field preparation	Two ploughing and planking	Two ploughing and planking	Nil
3.	Variety	RGN48, RGN229 and DRMRIJ31	Own procured seed	Full
4.	Time of sowing	October 15 to November 15	October 01 to November 30	Partial
5.	Method of sowing	Line sowing (45×10 cm^2)	Line sowing (30×10 cm^2)	Partial
6.	Thinning	15-20 DAS	No thinning practice	Full
7.	Seed treatment	Mancozeb 50 WP @ 2 g kg^{-1} seed and Thiamethoxam 25 WG @ 2 ml kg^{-1} seed	Without seed treatment	Full
8.	Biofertilizer	PSB @ 20 g kg^{-1} seed	No biofertilizer treatment	Full
9.	Seed rate	4 kg ha^{-1}	6 kg ha^{-1}	Full
10.	Fertilizer dose	N-P_2O_5- K_2O-S-Zn; 90-40-00-40-03 kg ha^{-1}	N-P_2O_5- K_2O; 18-46-00 kg ha^{-1}	Partial
11.	Weeding	Pre emergence application of pendimethalin 37.8 CS @ 3 L ha^{-1} and one hand weeding at 45 DAS	Two manual weeding	Partial
12.	Irrigation	As per soil type at Critical stages (vegetative growth and pod development)	As per need based	Partial
13.	Plant protection measures	Thiamethoxam 25 WG@ 0.4 g $litre^{-1}$ of water, Imidacloprid 17.8 SL @ 250 ml ha^{-1}, Mancozeb 80WP @ 2 g $litre^{-1}$ of water. Application on thebasis of ETL (Economic threshold level)	No application, application at improper time and doses.	Full

demonstration crop was done during mid-October to mid-November. The crop of mustard under demonstration was spaced at 45cm row to row using the seed rate at 4.0 kg ha^{-1}. The recommended dose of fertilizers including N, P, S and Zn were applied under the demonstration plots using urea, DAP, elemental sulphur and zinc sulphate, respectively. The amount of nitrogen supplied through DAP and sulphur through zinc sulphate was subtracted from the respective fertilizer and the amount so arrived was applied through urea and zinc sulphate. Half of the nitrogen and full amount of phosphorus, sulphur and zinc were applied as basal in the respective plots. The improved package of practices include improved varieties (RGN 48, RGN 229 and DRMRIJ 31), seed treatment with fungicides(Mancozeb 50 WP @ 2 g kg^{-1}), insecticide (Thiamethoxam 25 WG @ 2 ml kg^{-1} seed) and biofertilizers (PSB culture), (Carbendazim 2 g kg^{-1} seed), weed management (Pendimethalin 37.8 CS @ 3 l ha^{-1} and one hand weeding at 45 DAS) and pest management (Thiamethoxam 25 WG @ 0.4 g l^{-1} of water, Imidacloprid 17.8 SL @ 250 ml ha^{-1}, Mancozeb 80WP @ 2 g l^{-1} of water) was followed. Recommended irrigations at critical stages were applied to the crop. The performance of Indian mustard under the demonstrations were compared with the farmers' practice which include 6 kg ha^{-1} self procured seed without seed treatment and use of only DAP fertilizer. The results were economically analyzed in terms of B:C ratio and net returns to re-establish the viability. The yield and economics of data were obtained from 251 respondents from an area of 110.5 hectare area for the period of six years. The yield data were collected from both the demonstration plots and farmers' practice plots by random crop cutting methods and analyzed using simple statistical tools. The crops were harvested at perfect maturity stage with suitable method and yield data was collected. Under the investigation, technology yield gap, extension yield gap and technology index (Samui et al., 2000) were calculated using following formulae given hereunder:

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

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

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

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

Unlikely, eeconomics of the demonstrations under improved technology and farmers' practice were recorded. Based on economics, additional cost, additional returns, effective gain and incremental B:C ratios were calculated. These economic parameters were analyzed using the formulae given below

(Shivran et al., 2020):

Additional cost (₹ ha^{-1}) = Demonstration cost (₹ ha^{-1})-Farmers' practice cost (₹ ha^{-1})

Additional returns (₹ ha^{-1}) = Demonstration returns (₹ ha^{-1}) -Farmers' practice returns (₹ ha^{-1})

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

Incremental B:C ratio = Additional returns (₹ ha^{-1}) ÷ Additional cost (₹ ha^{-1})

For analyzing the above parameters of economics, cost of cultivation includes cost of inputs like, seed, fertilizer, pesticides were purchased by the farmers' themselves used under the treatment farmers' practice. However, the inputs used under demonstration plots were supplied by the Krishi Vigyan Kendra, Bikaner-II. Additionally, the charges towards labour, sowing, post-harvest operations etc. were paid by the farmers' individually. Unlikely, for obtaining input cost, the sum of expenditure on land preparation, seed, sowing, fertilizer, insecticide, fungicide, herbicide, irrigation, labour and harvesting cost, etc. were calculated from each plot. The farmer's family labour was not taken into consideration in the present study. The gross return, net return was calculated considering, cost of cultivation, input cost, output cost including grain yield at prevailing market price during the course of study years.

3. Results and Discussion

3.1. Technology interventions v/s farmers' practice

Before commencement of the front-line demonstrations at the farmers' field, participatory rural appraisal was undertaken. Based on this, the gap between farmers' practices and improved technology of Indian mustard cultivation in Bikaner districts of Rajasthan are presented in Table 1. Among varying technological components, full gap was observed in the components viz; improved varieties, thinning, seed treatment, biofertilizer, seed rate and plant protection measures. However, partial gap was observed for the components viz; time of sowing, method of sowing, fertilizer dose, weeding and irrigation. Although, no gap was noticed for the farming situations and field preparation. These gaps noticed at the farmers' field are ascribed to the slow pace of extension machineries, coupled with unreached public extension system, poor accessibility of advanced or improved agro-technologies especially among smallholder farmers and other vulnerable groups (Shivran et al., 2020; Babu et al., 2013; Reddy and Swanson, 2006). Further, farmers used local or old varieties of low yield potential instead of newly released varieties with improper application of improved recommended package technologies. The gap further aggravated due to non-availability of good quality seed well in advance at the time of sowing and lack of awareness were also some of the other important reasons for low productivity at farmer's field (Kumari et al., 2007; Shivran et al., 2020).

3.2 Indian mustard yield

A year wise comparison (2013-14 to 2018-19) of yield levels under front-line demonstrations and farmers' practice has been shown in Table 2 and depicted in Figure 1. It is evident from the results that under demonstration plot grain yield of mustard was found to be substantially higher than that of farmers' practice during all the years of demonstrations. The grain yield under demonstration ranges from 1550–2600 kg ha^{-1} as compared to farmers' practice, wherein it was recorded to the tune of 1350- 2100 kg ha^{-1} during the study period. Average yield of 251 demonstrations worked out to 2154 kg ha^{-1} from improved technology whereas the average yield obtained in case of farmers' practice was 1711 kg ha^{-1}. These results envisage that the adoption of improved production technology of mustard cultivation enhanced average yield by 25.89% (Table 2) over farmers' practice. The variety DRMRIJ 31 fetched higher grain yield of 2600 kg ha^{-1} during the year 2017-18. The improved technology leads to average yield enhancement to the tune of 14.81 to 33.33% over farmers' practice (local check). On an average (2013-14 to 2018-19), 25.94 per cent increase in grain yield was noticed under demonstration. The results also revealed that grain yield under demonstration as well as under farmers' practices were higher than the district and state average yield during all the years of investigation. It is interested to mention that, on an average, 1032 kg ha^{-1} higher grain yield of Indian mustard was recorded due to front-line demonstration over district average. Similarly, higher grain yield of Indian mustard at 727 kg ha^{-1} was also recorded under front-line demonstration over state average. Moreover, higher grain yield was also recorded under farmers' practice over district average and state average. It was due to use of high yielding improved varieties, improved agronomic practices, timely

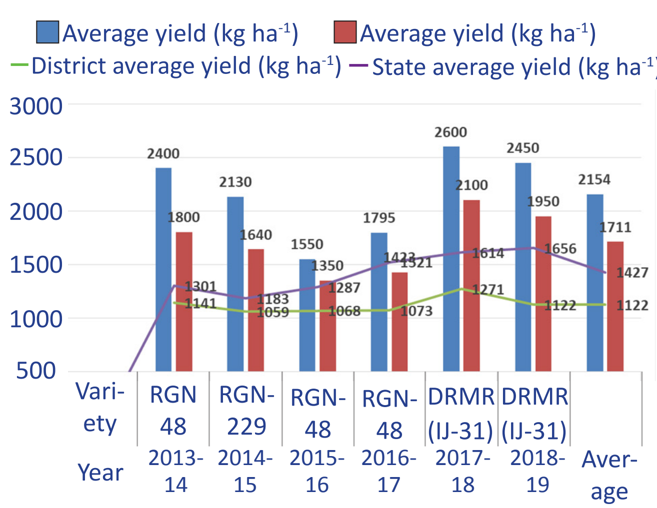

Figure 1: Comparision of demonstration and farmers' practice seed yield with the district and state average yiels of mustrad

Table 2: Performances and yield under demonstration and yield analysis of Indian mustard in Bikaner district of Rajasthan

Year	Variety	No. of demonstrations	Area (ha)	Average yield (kg ha^{-1})		% increase in yield over FP	District average yield (kg ha^{-1})	Yield (kg ha^{-1}) over district average		State average yield (kg ha^{-1})	Yield (kg ha^{-1}) over state average	
				Demo	FP			Demo	FP		Demo	FP
2013-14	RGN 48	30	15.0	2400	1800	33.33	1141	1259 (110.34)	659 (57.76)	1301	1099 (84.47)	499 (38.36)
2014-15	RGN 229	20	10.0	2130	1640	29.88	1059	1071 (101.13)	581 (54.86)	1183	947 (80.05)	457 (38.63)
2015-16	RGN 48	30	15.0	1550	1350	14.81	1068	482 (45.13)	282 (26.40)	1287	263 (20.44)	63 (4.90)
2016-17	RGN 48	75	30.0	1795	1423	26.14	1073	722 (67.29)	350 (32.62)	1521	274 (18.01)	-98 (-6.44)
2017-18	DRMRIJ 31	21	10.5	2600	2100	23.81	1271	1329 (104.56)	829 (65.22)	1614	986 (61.09)	486 (30.11)
2018-19	DRMRIJ 31	75	30.0	2450	1950	25.64	1122	1328 (118.36)	828 (73.80)	1656	794 (47.95)	294 (17.75)
Total/ Average		251	110.5	2154	1711	25.89	1122	1032 (91.98)	589 (52.50)	1427	727 (50.95)	284 (19.90)

Demo= Demonstration; FP: Farmers' practice; *Figures in parenthesis denotes the % change under demonstrations and FP over the district/state average yield for the particular year

weed management, balanced application of fertilizer and timely control of pest and disease at economic threshold level. Gangwar and Katiyar (2017) showed that the yield of mustard increased from 15.16 to 17.37 percent over farmers' practice during the demonstration period from 2013-14 to 2015-16. Further, improved varieties, recommended fertilizers and biofertilizers (Saha et al., 2015), nitrogen and sulphur (Mohiuddin et al., 2011), phosphorus and sulphur (Kumar and Yadav, 2007) fetched yield improvement in mustard. Yield improvement owing to demonstrations has also been reported by Sagar and Chandra 2004; Singh et al., 2016; Preeti et al., 2017.

3.3. Technology yield gap

The technology yield gap is the difference or gap between the demonstrations yield and potential yield. The technological gaps in adoption of Indian mustard production technologies under demonstrations and local farmers' practices were measured. The major technological gaps were observed regarding improved varieties, seed rate, thinning, time of sowing, method of sowing, fertilizer dose, biofertilizers, weeding, irrigation management and plant protection measures (Table 3). The technology yield gap ranges from 157–1374 kg ha^{-1} with an average technology yield gap recorded at 655 kg ha^{-1} (Table 3) during all the years of study. Moreover, the minimum technology yield gap of 157 kg ha^{-1} was recorded during the year 2017-18 under the variety DRMRIJ 31 and maximum of 1129 kg ha^{-1} during the year 2016-17 using the variety RGN 48. Under the present investigation, on an average, the technology yield gap of 650 kg ha^{-1}shows the potential of improved varieties and recommended package of practices. Overall, the yield under demonstration plots exceeded that of farmers' plots in all the demonstrated plots in real farm situation. Such enhancement in yield might be attributed to adoption of newly released high yielding varieties, improved agro-techniques in demonstrations which resulted in higher grain yield than that in the farmers' practices (Dayanand et al., 2012; Choudhary and Suri, 2014).

3.4. Extension yield gap

The extension yield gap is the difference or gap between the yield under demonstration plot and farmers' practice (control) plot. The extension yield gap ranges from 200–600 kg ha^{-1} with an average extension yield gap of 443kg ha^{-1} (Table 3) during

Table 3: Gap analysis in Indian mustard under front-line demonstrations and farmers' practice in Bikaner district or Rajasthan

Year	Variety	Technology yield gap (kg ha^{-1})	Extension yield gap (kg ha^{-1})	Technology index (%)
2013-14	RGN 48	524	600	17.92
2014-15	RGN 229	438	490	17.06
2015-16	RGN 48	1,374	200	46.99
2016-17	RGN 48	1,129	372	38.61
2017-18	DRMRIJ 31	157	500	5.69
2018-19	DRMRIJ 31	307	500	11.14
Average		655	443	22.90

all the years of demonstrations. So as to enhance the farmers' income, there is need to decrease this wider extension gap through implementation of latest agro-techniques (Balai et al., 2012; Dayanand et al., 2012; Meena et al., 2012). Singh et al. (2016) also reported an extension gap ranging from 275–508 kg ha^{-1}under FLD demonstration and farmers' practices over the years. Similarly, extension gap to the ranging from 470 to 670 kg ha^{-1} over the years has also been reported by Singh et al. 2007.

3.5. Technology index

The technology index shows the feasibility of new technology at the farmers' fields and the lower the value of technology index more is the feasibility of the technology. The average technology index was 22.90 percent in district (Bikaner) during study period (Table 3). Further, the technology index under the investigation reported to the range from 5.69 per cent during 2017-18 to 46.99 per cent during 2015-16. While working at Lucknow on mustard Singh et al. (2007) also reported technology index of 15.00 to 33.75 per cent over the years. The technology index infers that, there is ample scope for improvement in production and productivity of mustard in the district. Similar findings have also been reported by Singh and Kumar (2012); Dutta (2016); Dhaliwal et al. (2018); Kumar et al.(2019) and Kaur and Aulakh (2020).

3.6. Economics

Economics, an important parameter to reject or accept the technology was estimated under the study. The economics of the improved technology over farmers' practice were calculated using the prevailing market prices of the inputs and outputs during the particular year (Table 4; Figure 2). From the investigation, it was noticed that the cost of cultivation for raising Indian mustard under demonstration ranged from ₹ 23,550 to ₹ 28,000 ha^{-1} with an average of ₹ 26,077 ha^{-1}. However, under farmers' practice (control), as against in demonstration the cost of cultivation of Indian mustard ranges from ₹ 20,000 ha^{-1} to ₹ 26,301 ha^{-1} with an average of ₹ 24,364 ha^{-1}. Under the present investigation, front-line demonstrations fetched higher net returns to the tune of ₹ 27,275ha^{-1} to ₹ 77,000 ha^{-1} with the mean of six yeas were ₹ 50,740 ha^{-1}. However, under farmers' practices the net returns ranged to the tune of ₹ 20,825 ha^{-1} to ₹ 58,000 ha^{-1} over the years and its average value fetched to ₹ 36,636 ha^{-1}. Under the study, additional returns fetched from ₹ 6,450 ha^{-1} to ₹ 19,000 ha^{-1} with average additional returns of ₹ 14,107 ha^{-1}. As a result of demonstrations, effective gain recorded from ₹ 6,200 ha^{-1} to ₹ 18,000 ha^{-1} with an average over the years to the tune of ₹ 12,393 ha^{-1}. Further, on an average, additional cost of ₹ 1,714 ha^{-1} was incurred with the incremental cost benefit ratio of 8.23. Given the economic analysis in terms of benefit-cost ratio, it was fetched 2.75 (2013-14), 2.36 (2014-15), 2.11 (2015-16), 2.82 (2016-17), 3.85 (2017-18) and 3.87 (2018-19) following front-line demonstrations interventions at farmers' field. On the same situation following farmers' practice, fetched lower benefit-cost ratio to the tune of 2.09 (2013-14), 2.03 (2014-15), 1.85 (2015-16), 2.63 (2016-17), 3.23 (2017-18) and 3.35 (2018-19). On an average, benefit-cost ratio under front-line demonstrations and farmers' practice was recorded 2.95.and 2.50, respectively. The higher benefit-cost ratio under demonstrations ascribed due to higher yield obtained under improved technology as compared to farmers' practice. Hence higher benefit-cost ratio proved the economic viability of the technology interventions and convinced the farmers' on the utility of improved technologies. Similar economic benefits owing to adoption of improved technology interventions were also reported by Choudhary and Suri (2014) Meena and Dudi (2018); Meena and Singh (2019).

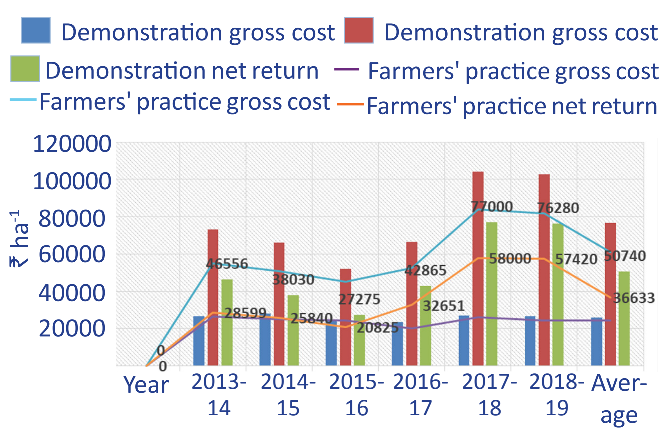

Figure 2: Economics of mustrad demonstration and farmers' practice

Table 4: Economics of the front-line demonstration and farmers' practice in Indian mustard

Year	Variety	Demonstration				Farmers' practice				AC	AR	EG	ICBR
		CC	GR	NR	B : C ratio	CC	GR	NR	B : C ratio				
2013-14	RGN 48	26,644	73,200	46,556	2.75	26,301	54,900	28,599	2.09	343	17,957	17,614	52.35
2014-15	RGN 229	28,000	66,030	38,030	2.36	25,000	50,840	25,840	2.03	3,000	12,190	9,190	4.06
2015-16	RGN 48	24,650	51,925	27,275	2.11	24,400	45,225	20,825	1.85	250	6,450	6,200	25.80
2016-17	RGN 48	23,550	66,415	42,865	2.82	20,000	52,651	32,651	2.63	3,550	10,214	6,664	2.88
2017-18	DRMRIJ 31	27,000	104,000	77,000	3.85	26,000	84,000	58,000	3.23	1,000	19,000	18,000	19.00
2018-19	DRMRIJ 31	26,620	102,900	76,280	3.87	24,480	81,900	57,420	3.35	2,140	18,860	16,720	8.81
Average		26,077	76,818	50,740	2.95	24,364	60,996	36,633	2.50	1,714	14,107	12,393	8.23

CC: Cost of cultivation (₹ ha^{-1}); GR: Gross return (₹ ha^{-1}); NR: Net return (₹ ha^{-1}); AC: Additional cost (₹ ha^{-1}); AR: Additional return (₹ ha^{-1}); EG: Effective gain (₹ ha^{-1}); 1 US$= ₹ 59.87, ₹ 62.13, ₹ 66.34, ₹ 64.80, ₹ 65.14 and ₹ 69.19 during 2014, 2015, 2016, 2017, 2018 and 2019, respectively

4. Conclusion

Improved Agro-technologies are more productive, remunerative and sustainable compared with farmers' practices. On an average, higher gross returns (₹ 76,818) ha^{-1}), net returns (₹ 50,740 ha^{-1}), effective gain (₹ 12,393 ha^{-1}), ICBR (8.23) and benefit-cost ratio (2.93) were fetched under demonstrations over farmers' practice. Thus, adoption of improved technologies demonstrated has a long-term impact on crop productivity, profitability and sustainability in Indian mustard over farmers' practice.

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