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Impact Analysis of Cluster Front Line Demonstration on Yield and Economics of Summer Sesame under Western Region of Gujarat

Traloki Singh[1], Rahul Dev[2], Pankaj Nautiyal[3], Anjali Sahu[3] and Mohit Singh[3]

[1]ICAR-Central Arid Zone Research Institute, KVK, Bhuj, Gujarat (370 026), India
[2]ICAR-Central Arid Zone Research Institute, RRS, Bhuj, Gujarat (370 026), India
[3]ICAR-The Central Soil Salinity Research Institute, Krishi Vigyan Kendra Hardoi-II, Uttar Pradesh (241 203), India

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Corresponding rahul2iari@gmail.com

0000-0001-9182-8169

ABSTRACT

The study assessed the effectiveness of scientific cultivation techniques for sesame using improved varieties GT-4 and GJT-5 during 2021–2022 in Anjar, Bhuj, and Nakhatrana talukas of Kachchh district, Gujarat, India. Conducted over 11.6 hectares through 29 demonstrations by ICAR-CAZRI and Krishi Vigyan Kendra, Bhuj, India. The demonstration trials addressed the region's saline-alkaline sandy soils with pH levels ranging from 8.5 to 9.2 and significant nutrient deficiencies. Sesame was sown between mid-February and early March and harvested from late April to early May. Improved practices included using high-yielding varieties, seed treatment, timely sowing, line sowing, recommended fertilizer application, and integrated pest management. The demonstrations achieved a 17.18% increase in seed yield, with 941 kg ha^{-1} compared to 803.5 kg ha^{-1} from farmers' traditional practices. Technological gaps of 300 kg ha^{-1} over two years highlighted the need for better soil management, irrigation, and seed quality to achieve potential yields. Extension gaps, ranging from 124 to 151 kg ha^{-1}, emphasized the importance of farmer education in adopting advanced agricultural methods. The technology index declined to 17.49%, reflecting improved feasibility and adoption of the innovations over time. Economic analysis showed demonstration plots had higher net returns (₹ 44,406 ha^{-1}) and a superior benefit-cost ratio (2.85) compared to local practices (₹ 30,133 ha^{-1}; B:C ratio 2.57). Post-demonstration, significant adoption of improved practices such as field preparation, fertilizer application, and pest management was observed. This study underscores the role of CFLDs in enhancing sesame productivity, economic returns, and farmer adoption of modern agricultural practices in challenging agro-climatic conditions.

KEYWORDS: Sesamum, adoption, impact, technological gap, extension gap

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important and one of the India's most ancient oilseed crops. It is globally grown in an area of 11.74 mha with a production of 6.01 mt and 512 kg ha^{-1} productivity. India is a major producer of oilseed crops, including groundnut, mustard, rapeseed, sesame, castor, sunflower, soyabean, and safflower. Among the oilseed crops, sesame has been cultivated for centuries, particularly in Asia and Africa, for its high edible oil and protein content. It is one of the important oilseed crops in Indian agriculture. India is the largest producer and exporter of sesame in the world. It also ranks second in the world in terms of sesame-growing area (12.4%), with about 1.7 mha with a total production of 0.74 mt and productivity of 431 kg ha^{-1} (Anonymous, 2020). Sesame seed is a reservoir of nutritional components with numerous beneficial effects for human health promotion (Pathak et al., 2014). It has the oil content of about 46–64% and high dietary energy (6355 kcal kg^{-1}). A quarter cup of natural sesame seeds provides more calcium (351 mg) than a full cup of milk (291 mg). Sesame seed oil is a good source of various nutrients, including vitamins, flavonoids, omega-6 fatty acids and phenolic antioxidants and is very resistant to rancidity. Its oil also has antioxidant properties, which increase its storage quality by preventing oxidative decay. Sesame seeds are tiny, oval, which come in different colours, including white, yellow, black and red, depending on the variety. It is mainly cultivated in Madhya Pradesh (346.40 ha), Uttar Pradesh (375.44 ha), Rajasthan (281.51 ha), Gujarat (140.08 ha), West Bengal (240.84 ha), Andhra Pradesh (48.80 ha), Karnataka (34.95 ha), Maharashtra (32.14 ha), Tamil Nadu (30.6 ha), and Telangana (18.0 ha) (Anonymous, 2019–20). In Gujarat, major summer sesame crop growing districts are Surendranagar (54.40 ha), Junagadh (53.57 ha), Amreli (6.37 ha), Morbi (7.17 ha) and Kutch (4.90 ha) under irrigated conditions (Anonymous, 2018–19). However, the productivity of sesamum in Gujarat is still below average, mainly due to the use of low-yielding varieties (local) and poor soil and nutrient management. The gap between scientists' recommendations and farmers' actual adoption of modern agricultural practices is a common challenge in agricultural extension (Rohit and Singh, 2019). This gap often results in suboptimal use of available technologies, leading to lower productivity and yields of sesamum. FLDs enable farmers to observe and assess new practices and technologies under real-world farming conditions, thereby enhancing their confidence and willingness to adopt scientific methods. In the context of sesamum cultivation, the adoption of improved varieties and scientifically validated cultivation practices has been shown to significantly increase productivity. Introducing high-yielding varieties, optimized sowing techniques, integrated pest management, and balanced nutrient applications can substantially improve sesame yield (Yadav et al., 2020). By demonstrating the practical benefits of scientific practices, FLDs serve as an essential mechanism for closing the gap between research and practice, ultimately leading to higher agricultural yields and enhanced food security. In the present demonstration experiment, a frontline demonstration was conducted on the 29 farmers' fields to study the production potential of the new technologies under actual farm situation over the local farmers practices.

2. MATERIALS AND METHODS

The present study found the economics and yield analysis of frontline demonstrations on summer sesame on farmers' fields in the Kachchh district of Gujarat, India. The frontline demonstrations were conducted from February to May for two consecutive years (2021 and 2022) on 29 farmers' fields in the adopted villages of Anjar, Bhuj and Nakhatrana talukas (administrative block), Gujarat, India. A total of seven villages were selected at random for cluster frontline demonstrations (CFLDs). A detail of the methodology adopted in present investigation is summarized in Table 1; the area covered and places of CFLDs conducted are shown in Table 2. Before conducting CFLDs, we collected basic information on crop production techniques, soil characteristics, prevailing varieties, and the occurrence of insect pests through field P.R.A. surveys and farmer meetings to determine the current condition in sesame production and, as a result, necessary improvements in cultivation practices were implemented. Every cluster had a minimum of 10ha area, and each frontline demonstration was laid out in 0.4 or 0.8 ha. Farmers allotted specific areas for cultivating existing varieties with traditional crop cultivation methods. Improved practices with two high-yielding variety of sesame (GT-4 and GJT-5) and a whole package of practices were demonstrated in different locations in 11.6 ha acreage. The experiment region soil was sandy to sandy loam, mostly saline-alkaline with pH and E.C. values ranging from 8.5 to 9.2 and 0.9 to 4.5 dS m^{-1}, respectively, and with low available nitrogen, phosphorus, essential micronutrients and organic carbon.

In both years, the seeds were sown from mid-February to the first week of March under irrigated conditions, and crop was harvested from last week of April to first week of May when capsules became pale yellow and a few capsules dry out. All essential inputs such as seed, fertilizer and plant protection chemicals were applied to crops as per the recommended package. Farmers chosen for CFLDs were instructed and trained to manage crops using the recommended practice package. Farmers, on the other hand, were permitted to carry out their own practices in a farmers' practice or a local check. Awareness programs on the importance of improved

Table 1: Details of material and procedures used under improved practice and local check

Sl. No.	Operation	Demonstrated improved technology	Farmers' practice
1.	Variety	GT 4 and GJT 5	GT 1 and GT 2, GT-3
2.	Soil and Seed treatment	Bavistin @ 2 g kg^{-1} and Thiamethoxam @ 7 g kg^{-1} seed before one day sowing	Generally, not practiced
3.	Date of Sowing	2nd week of February	1st week of March
4.	Method of sowing and spac-ing	Line sowing, 45×15 cm^2	Broadcasting
5.	Fertilizer N-P-K-S and Appli-cation time	10 t FYM, N-25 kg+25 kg P_2O_5+S-20 kg+250 kg Gypsum ha^{-1}	5 tonnes N-100 kg+P-50 kg
6.	No. of Irrigation	6–8	10–12
7.	Weed management	Fluchloralin or Pendimathalin of 1.0 kg a.i. at pre-emergence stage	Hand weeding at 25–30 days after sowing
8.	Plant protection	Seed treatment with Thiamethoxam 30 F.S. @ 7 g kg^{-1} seed and Bavistin @ 2 g kg^{-1} seed. With the appearance of capsule borer and whitefly foliar spray with Chloropyriphos+cypermethrin @ 1.5 mlliter-1 and thiamethoxam 7 g l^{-1} water at 15 days interval	Seed treatment not practiced Spraying with Dimethoate @ 0.05% or Profenophos 35 ml Pump^{-1}

Table 2: Impact Analysis cluster front line demonstrations on yield gap analysis

Year	No. of demo	Area (ha)	Potential yield (kg ha^{-1})	Demo (I.P.)* yield (kg ha^{-1})	Local (F.P.)* yield (kg ha^{-1})	% yield increased over F.P.
2021	33	13.2	1241	858	734	17.05
2022	25	10.0	1241	1024	873	17.30
Mean	29	11.6	1241	941	803.5	17.18
SEm±	4.0	1.6	0.0	83.0	69.5	0.1
CV (%)	19.51	19.51	0.00	12.47	12.23	1.03

varieties and new sesame production technologies were conducted by the K.V.K. staff before the start of the season at all locations. For the comparison study, data on several parameters such as seed yield, percent insect-pest, and disease incidence were gathered separately from improved practice (I.P.) and farmers' practice (F.P.). Furthermore, data were tabulated and analyzed by using statistical tools. The extension gap, technology gap and technology index were worked out as per Samui et al. (2000) as given below.

% increase in yield =(Yield gain in I.P.plot (kg ha^{-1})-Yield gain in F.P.plot (kg ha^{-1})/Yield gain in I.P.plot (kg ha^{-1}))×100

Technology gap=Potential yield–Demonstration yield

Extension gap=Demonstration yield-Local check

Technology index (%)=(Potential yield-Demonstration yield/ Potential yield)×100

Impact on yield (% change)=(Yield of Demonstration plot -Yield of farmers practice/Yield of farmers' practice)×100

Impact on yield (% change) =(No. of adopters after FLD – No. of adopters before FLD/ No. of adopters before FLD)×100

3. RESULTS AND DISCUSSION

3.1. Seed yield

The yield of sesame was superior in the demonstration plot as compared to local check throughout summer, 2021 and 2022, according to the data presented in Table 2 shows that better technical intervention led in a 17.18% higher sesame seed production of 941 kg ha^{-1}compared to 803.5 kg ha^{-1} recorded with existing techniques (farmers practise) as shown in Table 2. Previously, Tetarwal and Singh (2021) conducted four years CFLDs on groundnut, that documented 18.46% higher pod yield in the improved practice (IP) over farmers' practice. Similarly, Madhushekar et al. (2022) recorded a 12.53% increase from farmer's practice (2362 kg ha^{-1}) to 2659 kg ha^{-1} in demonstration plot. The % increase in yield of demonstration plots over farmers' plots was 17.18%. This seed yield increase of demonstration plots was due to the recommended package and practices followed under the supervision of K.V.K. scientists. Use of improved and recommended variety of sesame (GT-5 and GJT-7), optimum sowing time, proper seed treatment, line sowing, recommended dose of fertilizers, integrated weed and plant protection measures followed under CFLDs enhanced the yield of sesame compared to farmers' practices.

3.2. Technological gap

The technology gap indicated the gap between the demonstration yield and potential yield. A technology gap of 383 kg ha^{-1} was recorded in 2021 and the lowest was obtained 217 kg ha^{-1} in 2022. The average technological gap of two years was recorded 300 kg ha^{-1} (Table 3). It is shown that there is still a gap in technology demonstration, which is why adopting farmers cannot achieve the potential yield of improved practices. The technology gap observed may be attributed to dissimilarity in the soil condition, climatic conditions, lack of good quality seed, timely irrigation and location specific crop management practices. Hence, the availability of quality inputs and location-specific practices are necessary to fill the gap between potential and demonstration yields. On an average Malathi et al. (2024) documented 2.11 q ha^{-1} of technological gape in sesame crop. While, Tetarwal and Singh et al. (2021), obtained 457 kg ha^{-1} of technological gap in kharif groundnut in Kachchh district of Gujarat.

Table 3: Yield gap analysis, extension gap and technology index of the front line demonstration

Year	Extension gap (kg ha^{-1})	Technology gap (kg ha^{-1})	Technology index (%)
2021	124	383	30.86
2022	151	217	17.49
Mean	137.5	300	24.18
S. D	19.09	117.38	9.45
S.Em±	13.5	83.0	6.7
CV (%)	13.89	39.13	39.11

3.3. Extension gap

This extension gap is a metric to determine the yield difference between a demonstration plot and a plot already used (farmers practice). The higher extension gap of 151 kg ha^{-1} was obtained during the years 2022–23 as compared 124 kg ha^{-1} in the year 2021–22. The extension gap ranged between 124 kg ha^{-1} and 151 kg ha^{-1} in the districts of Kutch. It emphasizes the need to educate the farmers about improved technologies like high-yielding varieties and improved agricultural practices by scientists to change this extension gap. This improvement indicates a positive shift towards adopting more effective agricultural techniques, suggesting that present investigation were making a significant impact on productivity. The consistent range of the extension gap highlights the potential for further yield growth, encouraging collaboration among farmers and agricultural stakeholders to share knowledge and resources, ultimately leading to more sustainable and profitable farming practices in the region. An experiment in arid areas of Rajasthan with Sesame variety (RT-351) shows an extension gap of 1.35 q ha^{-1} (Meena et al., 2023). Similar findings were also reported by Singh and Tetarwal (2022) and Kumar et al. (2023) in other crops.

3.4. Technology index

The technology index indicates the feasibility of new technology at the field level, as it is an essential tool for judging the adoption and impact of different technologies (Kumar et al., 2023). The lower the value of the technology index, the greater the feasibility of the technological intervention (Jeendar et al., 2006). According to the results (Table 3), the highest technology index value of 30.86% was recorded in *summer* sesame during 2021–22, while the lowest technology index value of 17.49% was recorded in summer sesame 2022–23. During two consecutive years of cluster frontline demonstration on the oilseed programme, the sesame average technology index in summer sesame was 24.18%. Tetarwal and Singh (2021) reported, 16.76% average technology index in kharif groundnut in Kachchh district of Gujarat and while, Singh and Tetarwal (2022) found similar technology index of 13.11%, in mustard crop in arid zone of Gujarat. The considerable variation in the technology index between different districts of the different states might be due to soil fertility, climatic conditions and farmers' adoption % of the technology. Previously a three years FLD programme on Cotton in Khammam District of Telangana reported technology gape of 1043 kg ha^{-1} with a technology index of 32.09% (Shekar et al. (2022)

3.5. Economics returns

The economic analysis of summer sesame cultivation presented in Table 4 showed the viability of improved demonstrated technology over local check was calculated depending on prevailing cost of inputs and output prices and represented in terms of benefit-cost ratio (B:C Ratio). The two-year average cost of cultivation of summer sesame was 23725 ₹ ha^{-1} in local practice and 25025 ₹ ha^{-1}in demonstrations. The net returns in the demonstration were obtained as 44406 ₹ ha^{-1} in demonstrations compared to the farmers' practice 30133 ₹ ha^{-1}. The B:C ratio in the demonstration was calculated as 2.85 and was 2.57 in farmers' practice. The additional returns over the farmers' practice was highest in 2022–23 (10573 ₹ ha^{-1}) followed by 2021–22 (7711 ₹ ha^{-1}). The economic analysis indicates that the net returns and B:C ratios were higher in demonstration plots than in farmers' plots. The higher net returns and B:C ratio in the demonstration might be due to increased yields and higher market price because of the better output quality by adopting improved technologies. For sesame,

Table 4: Economics analysis of cluster front line demonstrations on sesamum at farmers' field

Year	Cost of cultivation (₹ ha^{-1})		Gross return (₹ ha^{-1})		Net return (₹ ha^{-1})		Additional return (₹ ha^{-1})	B:C ratio	
	IP*	FP	IP	FP	IP	FP		I.P.	F.P.
2021	24850	23500	62694	53633	37844	30133	7711	2.52	2.28
2022	25200	23950	80179	68356	54979	44406	10573	3.18	2.85
Mean	25025	23725	71436.5	60994.5	46411.5	37269.5	9142	2.85	2.57
S.D	247.49	318.20	12363.76	10410.73	12116.27	10092.54	2023.74	0.47	0.40
SEm±	175.0	225.0	8742.5	7361.5	8567.5	7136.5	1431.0	0.3	0.3
CV (%)	0.99	1.34	17.31	17.07	26.11	27.08	22.14	16.38	15.71

the recommended approaches produced a higher average benefit-cost ratio (1:2.60) than the farmers' methods (1:2.15) (Meena et al. (2023). These findings align with previous finding on pigeonpea crop (Kumar et al., 2023). Balai et al. (2021) documented an average additional return (16,063.6), effective gain (14,335.8), net return (₹ 64,512.1 ha^{-1}) and benefit-cost ratio (3.49) in the DP as compared to farmer practice in CFD of Mustard (*Brassica juncea*) in Dholpur (Rajasthan) India.

As indicated in Table 5, the impact of adoption regarding the field preparation and usage of F.Y.M. for sesame crop before field demonstrations was 45.83%, which increased to 89.17% after cluster frontline demonstrations in adopted villages. A similar trend was observed in the adoption of high-yielding varieties, sowing time and spacing, and improved variety, with adopters rising from 61.67 to 87.50 and 36.67 to 81.67%, respectively. The number of adopters with fertilizer application, weed control and I.D.M.& I.P.M. increased from 42.50 to 91.67%, 44.17 to 90%, 40 to 76.67%, respectively, over the pre-and post-demonstration periods. The CFLD intervention practices significantly positively impacted the adoption of improved practices. Earlier, in mustard CFLD results showed; mean percent score (MPS) of 88.25, 86.00, 82.30, 74.62, 65.70, 64.00 and 62.50, percent pertaining to practices like irrigation management, seed rate and spacing, soil treatment and field preparation, time of sowing, fertilizer application, harvesting, threshing and storage and seed treatments, respectively (Balai et al., 2021). According to Singh et al. (2019), as compared to farmer practices, oil seed crops including sesame, groundnut, niger, linseed, and mustard exhibit improved cross returns, net returns, and benefit-cost ratios when improved varieties and locally available essential inputs like micronutrients.

Table 5: Impact of Cluster frontline demonstrations on the adoption of improved practices on yield of summer sesame

Sl. No.	Improved practices	No. of adoptions (N=120) Before demonstration	No. of adoptions (N=120) After demonstration	Change in no. of adopters	Impact (% change)
1.	Field preparation and use of F.Y.M.	55 (45.83)	107 (89.17)	+52	+94.54
2.	Improved variety (G.T. 4, G.J.T. 5)	44 (36.67)	98 (81.67)	+54	+122.72
3.	Sowing time and spacing	74 (61.67)	105 (87.50)	+31	+41.89
4.	Nutrient management	51 (42.50)	110 (91.67)	+59	+115.69
5.	Weed management	53 (44.17)	108 (90.0)	+55	+103.77
6.	I.D.M. and I.P.M. practices	48 (40.0)	92 (76.67)	+44	+91.67

4. CONCLUSION

Sesame cultivation with CFLDs resulted in a 17.18% increase in yield (941 kg ha^{-1}) compared to farmers' practices (803.5 kg ha^{-1}). Economic research reveals increased net returns and a B:C ratio (2.85 vs. 2.57) due to improved agronomic methods such as high-yielding varieties, correct sowing, and integrated pest management. The significant benefit-cost ratio explained the demonstration's economic feasibility, which persuaded the farmers to implement the intervention.

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