

SCALING UP OF SESAME PRODUCTION UNDER CLUSTER FRONTLINE DEMONSTRATION TECHNOLOGY TRANSFER PROGRAMME IN PUNJAB, INDIA

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ABSTRACT

The present investigations were undertaken to assess the effectiveness of demonstrated technology of sesame cultivation at farmers' fields for their awareness with the objective of narrowing yield gaps in sesame crop in the rain fed areas of Punjab, India. A total of seventy-five Cluster Frontline Demonstrations (CFLDs) were conducted on improved farm technology of sesame, in which the full package of agronomic practices for its cultivation were used with special focus on improved cultivars and Integrated Pest Management (IPM), which are major constraints in sesame production. The performance of the technology demonstrated under the CFLDs was compared with that of the traditional farmers' practice. The yield enhancement, technological gap and extension yield gaps along with the economic analysis were studied for the three years during Kharif 2017-18 to Kharif 2019-2020. The average technology gap, extension yield gap and technology index of 1.43 quintal per hectare (q/ha), 1.54 q/ha and 20.4%, respectively, were recorded. The improved farm technology package demonstrated showed significant enhancement in the profitability of oilseeds in terms of gross returns and net returns besides additional returns (Rs. 9098–15215/- per ha) and incremental benefit-cost ratio (3.54–4.40). The demonstrated farm technology was found to have huge potential to enhance sesame productivity and profitability, thereby enabling farmers to earn better livelihood under normal and collateral farming situations.

Keywords: Frontline demonstrations, Economics, Sesame, Extension gap, Productivity, Technology index

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INTRODUCTION

Sesame (*Sesamum indicum* L.) is herbaceous annual diploid species belonging to the order Lamiales, family Pedaliaceae, cultivated for its edible seed and oil. Sesame is also known as til, gingelly, benne seed or simsim (Bhatnagar and Krishna, 2009). Due to its high oil content, delicious nutty aroma, and flavour, Sesame is popularly labeled as 'Queen of oilseeds' (Johnson *et al.*, 1979). Traditionally considered as a healthy food in Asian countries (Miyake *et al.*, 2005), its seed is high in protein (20-28%), oil (48-55%), sugars (14-16%), fiber (6-8%), minerals (5-7%), moisture (6-7%), vitamin B1, vitamin E apart from being an excellent source of phosphorous, iron, magnesium calcium, manganese, copper and zinc, antioxidants, lignans, phytosterols, phytates and PUFA (linolenic acid, oleic acid, palmitic and stearic acid) (Pathak *et al.*, 2014) with several medicinal and cosmetic uses (Yadav *et al.*, 2020). The oil extracted from its seeds has a pleasant, mild taste and excellent stability due to natural antioxidants, i.e., sesamin, sesamolin, and sesamol (Lyon, 1972, Myint *et al.*, 2020), and thus shows a high degree of resistance to oxidation and rancidity (Bedigian and Harlan, 1986).

Sesame is mostly grown in arid and semi-arid areas with mild-to-severe water deficit stress and thus is suitable for cultivation in rain fed conditions. This crop shows excellent ability to thrive in a harsh environment, requires limited water, fertilizer and shows considerable levels of tolerance for insects and diseases. However, its sustainable production is limited by its sensitivity to water-logging, salinity, and chilling (Tripathy *et al.*, 2019). A variety of insect pests attack this crop causing an average loss of 25 per cent of potential production worldwide. In addition to this, blight, phyllody, stem anthracnose, charcoal rot and mildew are significant diseases in sesame (Weiss, 2000). Consequently, the sesame yield is highly dependent on the growing environment, the cultivars and cultural practices.

However, the global sesame consumption is steadily increasing primarily due to increasing health awareness. Worldwide sesame seed consumption was USD 6559.0 million in 2018, and it is projected to reach USD 7244.9 million by 2024, with a CAGR (compound annual growth rate) of 1.7 per cent (Myint *et al.*, 2020). Asia and Africa produce nearly 97 per cent of the world's supply of sesame. The world sesame production is about 60,16,000 metric tons (MT) with India contributing 12.4 per cent (7,46,000 MT) (FAOSTAT 2020). India has 1.73

million ha area under sesame which is 14.7 per cent of the total area under sesame in the world (11.74 million ha). The average yield of sesame in India (4.31 q/ha) is far lower than that of the world average (5.12 q/ha). The top four states in India in terms of acreage under sesame are Uttar Pradesh (362 thousand ha), Rajasthan (315.2 th ha), Madhya Pradesh (359 th ha) and West Bengal (227.7 th ha), whereas, West Bengal is the highest yielding (9.47 q/ha) state.

Before the introduction of paddy, sesame was cultivated on a large scale in Punjab. However, the area under sesame reduced drastically over the years from 18,000 hectares during 1990-91 to 3,000 hectares during 2017-18 (Anonymous, 2019). During 2018-2019, sesame crop was cultivated on 200 hectares with an average yield of 2.4 q/ha in Ropar district of Punjab (Anonymous, 2020). The average productivity of sesame crop in the Ropar district is low, mainly due to lack of knowledge about the improved varieties, scientific cultural practices and ecologically sound integrated pest management practices. To meet the increasing demand of sesame, there is a need to promote the cultivation of this crop through the introduction of high yielding sesame varieties and improved cultivation practices, especially in the areas with low groundwater level, which will also serves the purpose of water conservation through crop diversification.

The program 'Cluster Frontline Demonstrations' has tremendous scope to bridge the technological gaps between crop yield and its production potential. It is a form of applied research conducted with the objective to demonstrate the improved farm technology under varied farming situations (Choudhary and Suri, 2014). The cluster frontline demonstration (CFLD) programmes on sesame crop have resulted in yield enhancement along with better economic returns than the conventional farming practices in other regions of India (Kumar *et al.*, 2018; Singh *et al.*, 2019; Kumar *et al.*, 2020). This approach provides a direct interface between researcher and farmer for the transfer of technology which had yielded promising results in various crops such as black gram (Kumar and Dev, 2020), chickpea (Patel *et al.*, 2019), lentil (Dubey *et al.*, 2018) and mustard (Singh *et al.*, 2020).

The present study was thus undertaken to know the impact of cluster frontline demonstration (CFLD) approach in sesame cultivation at farmers' fields under rain fed production systems in Ropar, Punjab.

MATERIALS AND METHODS

Study area: To achieve the objectives, seventy-five CFLDs were conducted in Ropar, Punjab in three years under rainfed conditions. For this purpose, diverse agro-socio-economic situations were selected i.e. the farmers selected for the study belonged to different

agroecological conditions (sub mountainous zone, undulating plain zone and flood plain zone) and varied economical categories according to land holding such as marginal (less than 1 hectare land), small (1-2 hectare land), semi medium (2-4 hectares), medium (4-10 hectares) and large (more than 10 hectares). Ropar district of Punjab is located between 30.97° N and 76.53°E and 260 m above mean sea level on the bank of river Satluj with Shivalik range spread along the opposite bank of the river. The selected study locale was characterized by well-drained sandy loam with medium soil fertility status.

Identification and ranking of major constraints: The farmers for the study were selected on the basis of agro-socio-economic survey, covering farmers from all agro-ecological and economic backgrounds. The selected farmers were interviewed to list out the major constraints being faced by them in the cultivation of sesame crop. Based upon the farmers' interviews, the ten most common constraints in sesame cultivation identified by them were shortlisted. A performa with the list of these ten shortlisted constraints was then prepared and distributed individually to the selected farmers. The farmers were asked to rank these constraints from 1 to 10, where 1 signified the most important constraint and 10 as the least important constraint. For each constraint, the number of farmers selecting the particular constraint under a particular rank was recorded. The quantification of this data was done by calculating Rank Based Quotient (RBQ) (Table 1) as given by Sabarathanam (1988), using the following formula:

$$RBQ = \frac{\sum f_i (n+1-i^{th})}{N \times n} \times 100$$

Where,

f_i = number of farmers reporting a particular problem under i^{th} rank,
 N = number of farmers
 n = number of problems identified

Cluster frontline demonstrations (CFLDs): CFLDs on improved production technology (Table 2) were conducted by Punjab Agricultural University Farm Science Centre (KVK), Ropar on sesame (*Sesamum indicum*) during Kharif 2017-18, 2018-19, and 2019-20 under rainfed conditions on 30 ha area at 75 locations in 8 villages of Ropar. In the demonstration plot, the complete package of agronomic practices was adopted (Anonymous, 2017). In these plots, special emphasis was laid on the improved cultivar (Punjab Til No. 2) and IPM which are major constraints in sesame production in Ropar, Punjab (Table 1). The performance of the demonstrated technology was compared with the farmers' practice (check). The crop yield from the demonstration plots as well as check plots was recorded and the cost of cultivation, gross returns, net returns and B:C ratio were

also computed. The data on major insect pests and diseases were also recorded.

Estimation of crop productivity and yield enhancements: The primary data on grain yield and farmers' practices were recorded and the yield increase in frontline demonstrations over farmers' practice was calculated using the following formula (Choudhary *et al.*, 2009):

$$\%YIOFP = \{(Average\ demonstration\ plot\ yield - Farmer's\ average\ plot\ yield) / Farmer's\ average\ plot\ yield\} \times 100$$

Where,

$$\%YIOFP = \text{per cent yield increase over farmers' practice}$$

Estimation of technology gap, extension gap and technology index:

The estimation of technology gap, extension gap and technology index was done using following formula (Samui *et al.*, 2000):

$$\text{Technology gap} = PY - DY$$

$$\text{Extension gap} = DY - LY$$

$$\text{Technology Index} = \frac{(PY - DY) \times 100}{PY}$$

Where,

PY = Potential yield of demonstrated variety,

DY = Demonstration yield

LY = Farmer's plot yield (Local check yield)

Economic analysis of CFLD on oilseeds: The cultivation cost of sesame included the cost of inputs like seed, pesticides and fertilizers purchased by the farmers (in check plots as per farmers' practice) and provided by the Farm Science Centre, Ropar (in demonstration plots). The hired labour, sowing charges, tractor operations, pesticide sprays, hoeing and postharvest operation charges (if any) paid by the farmers were also included in the cost of cultivation. The farmers' family labour was not taken into account in the present study. The gross and net returns were worked out by taking the cost of cultivation and the price of grain yield of sesame. Additional costs in CFLDs include expenditure on improved technological inputs and practices in CFLDs over farmers' practice. Likewise, the incremental benefit-cost ratio (IBCR) i.e. the ratio of additional returns and corresponding additional costs were calculated as followed by Vedna *et al.* (2007).

RESULTS AND DISCUSSION

The constraints in sesame cultivation were identified using the preferential ranking technique. The ranks given by the individual farmers to each constraint were used to calculate Rank Based Quotient (Table 1) which revealed that the lack of high yielding varieties of this crop was one of the major constraints in sesame cultivation with RBQ of 97.2. Other major constraints included lack of technical guidance regarding sesame

cultivation and incidence of phyllody disease with RBQ of 73.6 and 69.6, respectively.

Based on these constraints, a complete package of practices for the cultivation of the high yielding variety of sesame 'Punjab Til No. 2', with the potential yield of 7 q/ha and tolerance to phyllody & cercospora leaf blight diseases, was demonstrated (Table 2). Sarvanakumar (2018) also reported the lack of high yielding varieties of black gram as the primary constraint in its successful cultivation.

The transfer of improved sesame cultivation technology under CFLDs resulted in higher sesame grain yield in demonstration plots (4.40 to 6.62 q/ha) than that in the farmers' plot (2.54 to 5.15 q/ha), attributed to the adoption of recommended agriculture technologies in CFLDs during the period under study. The average yield obtained from the demonstration plots was 5.57 q/ha as compared to 4.03 q/ha under farmers' practice (Table 3). The yield under the demonstration plots ranged from 3.75 q/ha obtained during 2017-18 to 7.00 q/ha during the year 2019-20, the former being on the very lower side due to crop damage by wild animals. However, overall, there was a significant increase in yield obtained from the technology demonstrated as compared to the farmers' practice. The demonstration plots gave 38.21 per cent higher yield than the check plots. The enhancement in yield through demonstration of improved production technology under CFLD programme / technology demonstration has also been reported by various workers (Vedna *et al.*, 2007, Choudhary and Suri, 2014, Sharma *et al.* 2016, Meena and Singh, 2017).

The increase in yield is attributed to the use of improved variety, along with the recommended cultivation practices such as avoiding early sowing of the crop during June, which resulted in lesser jassid and phyllody incidence. In addition to this, the hand weeding at 21 days after sowing resulted in low weed infestation leading to better crop stand. The check plots, on the other hand, were heavily infested by the phyllody disease (Fig. 1) and had poor crop stand due to heavy weed infestation. The insect pest and disease incidence in demonstration plots were comparatively lesser than that in the check plots (Figs 1 & 2). In the demonstration plots, the highest incidence of phyllody was 11.43 per cent in the years 2017-18 and 2018-19, while in farmers' plots it was 28.57 per cent in the year 2018-19. Similarly, the highest incidence of blight in demonstration plots was 8.57 per cent in the year 2018-19 and in farmers' practice, it was 20.00 per cent in the same year. The higher disease incidence in farmers' practice was due to the early sowing of the crop and overuse of fertilizers. Both of these factors are favourable for the phyllody and blight in this crop. The major pest of the crop was the hairy caterpillar with the maximum incidence of 17.14 percent in demonstration plots in the year 2017-18 compared to 34.29 percent in farmers' practice during the same year

(Fig. 2). The highest incidence of jassid was 11.43 per cent in the demonstration plots during 2017-18 as compared to 22.86 per cent in the check plots during 2018-19. Capsule borer also infested the fields with the highest incidence of 8.57 per cent incidence in demonstration plot as against 14.29 percent incidence in the farmers' practice. The farmers' practice of overuse of nitrogenous fertilizers results in high incidence of sucking pests like jassids, which are also a carrier of phyllody disease. In demonstration plots, the insects were managed by mechanical control during the gregarious phase of the insect, which resulted in effective control of the same.

The technology gap in sesame was greatest (1.89 q/ha) during Kharif 2017-18 and the least (1.19 q/ha) during Kharif 2019-20, while the average technology gap was 1.43q/ha (Table 4). It was observed that technological gaps appear even after the CFLDs are conducted under the strict supervision of scientists. This may be attributed mainly to variations in soil fertility, distribution of rainfall under rainfed conditions, specific crop management problems, micro-level differences in weather and field operations adopted in order to harness the yield potential of crop under demonstration plots and menace of crop damage by wild animals which is highly prevalent in Ropar. This indicated the need for location-specific crop management recommendations to bridge the gap in potential and demonstration yields (Vedna *et al.*, 2007), besides disseminating the technical know-how on minimizing the local problems and strengthening of farm infrastructure. Similarly, a wide technological yield gap of 1.65 q /ha was observed in sesame crop (Singh *et al.*, 2014), 3.6 q/ha in green gram (Meena and Singh, 2017), 18.2 q/ha in soybean and 10.3 - 11.1 q/ha in mustard (Choudhary and Suri, 2014).

The fundamental concern for the successful development, dissemination, adoption and performance of improved technologies, particularly for marginal and small farmers lies in the careful planning of research, needful region-specific refinement and the use of appropriate extension methodologies. Higher extension yield gaps observed in the current study ranging from 1.41 q/ha to 1.64 q/ha (Table 4) over the years point out that there is a strong need to sensitize and encourage the resource-poor farmers to adopt improved sesame production technology. Similar findings on high extension yield gaps were reported by the earlier workers to the tune of 2.45-4.45 q/ha in chickpea (Patel and Patel, 2020) and 2.4-3.3 q/ha in sesame (Singh *et al.*, 2014).

The technology index indicates the feasibility of demonstrated farm technology in the farmers' fields

under existing agro-climatic situations (Vedna *et al.*, 2007; Choudhary *et al.*, 2009). As the technology index decreases, the feasibility of demonstrated farm technology under farmers' fields increases, and vice versa. The present studies revealed that the technology index varied from 17.0 to 27.0 per cent in sesame over the years which indicates that there exists a wide gap between the potential of demonstrated technology and its actual impact realised at farmers' fields under CFLDs. The lower average value of technology index in the present study (20.4 per cent) suggested the greater feasibility of the demonstrated technology in the district Ropar. The results suggested that the introduction of high-yielding varieties (HYVs) of the sesame crop with tested and recommended location-specific farm technology, its proper demonstration under CFLDs, intensive awareness campaign and improved farm infrastructure has potential for better technology adoption and higher productivity. These results are in conformity with the findings of Meena and Dudi (2018), who observed a technology index of 27.3 per cent in frontline demonstrations of green gram. Similar observations on technology index were also recorded in various other crops *viz.* Sesame (Kumar *et al.*, 2020); green gram (Meena and Singh, 2017); and lentil, field pea and black gram (Singha *et al.*, 2020) indicating the viability of improved technology demonstrated at farmers' fields. The CFLDs data revealed that the highest gross returns (Rs. 69534/ha) and net returns (Rs. 49534/ha) were recorded in sesame variety 'Punjab Til No.2', which was demonstrated at the farmers' fields during Kharif 2019-20 under the current study. The additional cost of cultivation of improved technology varied between Rs. 2300 to Rs. 3455/ha with additional returns of Rs. 9098 to Rs. 15215/ha in the present study (Table 5). Higher returns from demonstrations plots have also been recorded earlier in various CFLD programmes in green gram (Meena and Singh, 2017); sesame (Kumar *et al.*, 2018); and castor (Rai *et al.*, 2018). The incremental benefit-cost ratio (IBCR) ranged from 3.54 to 4.40 over the years. Demonstration on improved farm technology by various other workers also resulted in similar enhancement in monetary returns in terms of gross return, net return, additional return as well as IBCR (Vedna *et al.*, 2007, Choudhary and Suri, 2014; Yadav *et al.*, 2020). The economic analysis of the data showed that the transfer of improved technology and its adoption in sesame may considerably enhance the crop productivity and profitability besides providing a better livelihood option for farmers under rainfed farming situations.

Table 1: Ranking of constraints faced by farmers in sesame cultivation.

Sr. No.	Constraints	RBQ	Overall Rank
1	Poor availability of high yielding improved varieties	97.2	I
2	Lack of technical guidance	73.6	II
3	Incidence of Phyllody disease	69.6	III
4	Incidence of Hairy caterpillar	67.2	IV
5	Weed infestation	64.0	V
6	Low soil fertility	52.4	VI
7	Incidence of Blight	40.4	VII
8	Incidence of Jassid	30.4	VIII
9	Seed shattering losses in field at harvesting	28.4	IX
10	Poor market price	26.8	X

Table 2: Technology demonstrated vis-a-vis farmers' practice.

Problem identified	Farmers' practice/ Problems	Technology demonstrated
Varieties	Local unrecommended variety with low yield	High yielding improved variety Pb. Til No. 2
Lack of technical guidance	Lack of technical knowledge regarding cultivation of sesame	Production technology demonstrated
Incidence of Phyllody disease	Spray of Swift (Acetamiprid) @ 40-60 g/acre for control of Jassid	Sowing crop during first fortnight of July instead of sowing in June as early sown crop is more prone to phyllody disease, timely roguing out of diseased plants.
Incidence of hairy caterpillar	Spray of unrecommended insecticide Danitol (Fenprothrin) @ 100 ml/acre	Mechanical control by roguing out of infected plants during gregarious phase of the insects
Weed infestation	Spray of Turga Super (Quizalofop Ethyl) @ 300 - 400ml/acre	One hoeing operation at 21 DAS
Low soil fertility	Use of 75-90 Kg Urea per acre	Use of 45 Kg Urea per acre
Incidence of Blight	Spray of Dithane M-45 @ 600-800 g/acre	Fields kept weed free, excessive use of nitrogenous fertilizers was avoided
Incidence of Jassid	Spray of Swift (Acetamiprid) @ 40-60 g/acre	Sowing crop during first fortnight of July instead of sowing in June as early sown crop suffers heavy jassid attack
Shattering of seeds in field leading to yield loss	Reluctance in timely harvesting of crop at maturity	Crop harvested immediately when plants turn yellow and capsules just opened
Poor Market Price	Poor quality produce fetches lower market price	White bold seeds fetches higher market price

Table 3. Performance of the CFLDs on Sesame in Punjab, India.

Year	No. of FLD	Yield (q ha ⁻¹)						Yield increase over farmer's practice (%)
		Demonstration			Farmer's Practice			
		Maximum	Minimum	Average	Maximum	Minimum	Average	
2017	25	6.25	3.75	5.11	5.25	2.38	3.70	38.10
2018	30	6.60	4.70	5.79	5.00	2.50	4.15	39.51
2019	20	7.00	4.75	5.81	5.25	2.75	4.25	36.70
Mean	25	6.62	4.40	5.57	5.15	2.54	4.03	38.21

Table 4. Technology gap, extension gap and technology index in sesame cultivation.

Year	Technology gap (q ha ⁻¹)	Extension gap (q ha ⁻¹)	Technology Index (%)
2017-18	1.89	1.41	27.0
2018-19	1.21	1.64	17.3
2019-20	1.19	1.56	17.0

Mean	1.43	1.54	20.4
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Potential yield of demonstrated variety Pb. Til No.2 = 7.0 q ha⁻¹

Table 5. Economic analysis of CFLDs on Sesame in Punjab, India.

Crop/ variety	Season/Year	Cost of cultivation (in Rs ha ⁻¹)		Gross returns (in Rs ha ⁻¹)		Net returns (in Rs ha ⁻¹)		Additional Cost (in Rs ha ⁻¹)	Additional Returns (in Rs ha ⁻¹)	IBCR*	Selling price of grain produce (in Rs q ⁻¹)
		DP	FP	DP	FP	DP	FP				
Sesame/ Pb.Til No. 2	2017-18	19500	17200	40998	29686	21498	12400	2300	9098	3.96	8023
	2018-19	18750	15500	52110	37350	33360	21850	3250	11510	3.54	9000
	2019-20	20000	16545	69534	50864	49534	34319	3455	15215	4.40	11968

*IBCR - Incremental benefit-cost ratio

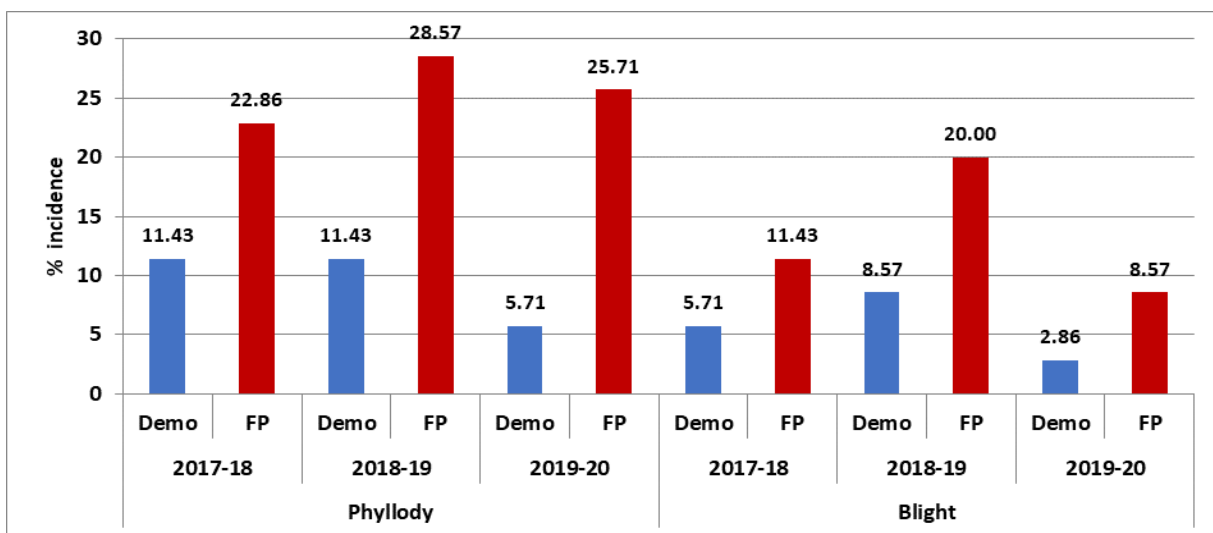


Figure 1: Disease incidence (%) in demonstration plots and farmers' practice (FP).

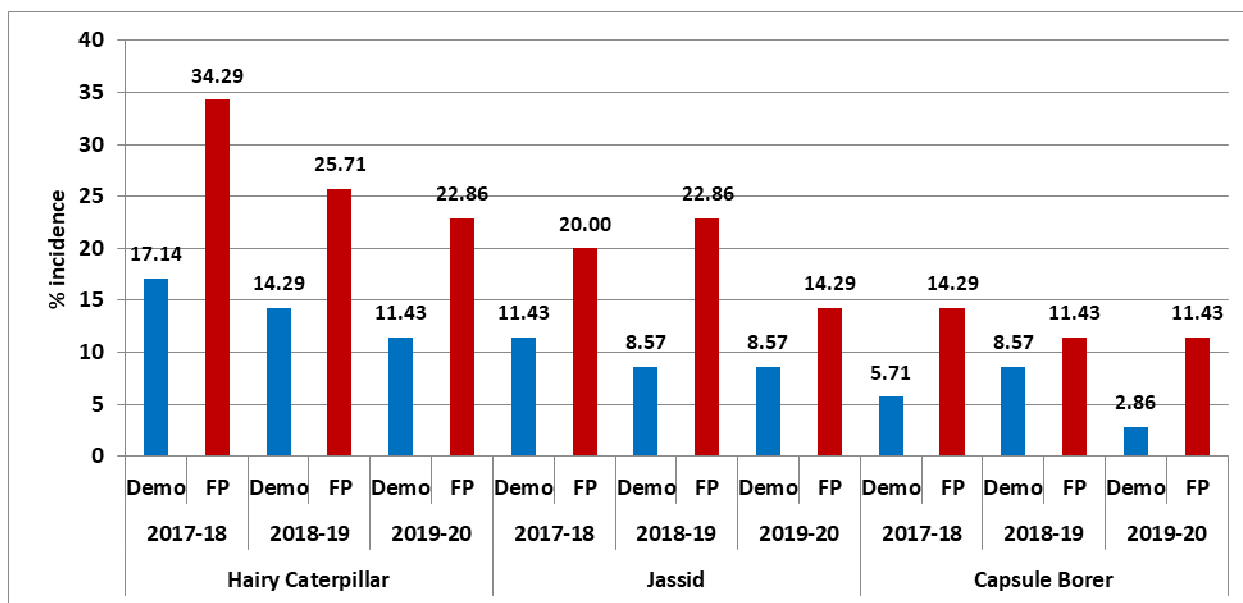


Figure 2: Insect pest incidence (%) in demonstration plots and farmers' practice (FP)

Conclusions: The study revealed that the improved technology package of sesame cultivation demonstrated at the farmers' fields under the cluster frontline demonstration programme resulted in enhancement in quantity as well as the quality of the produce, thus leading to higher economic returns. It was also observed that a wide gap exists in the potential yield, demonstration yield and farmers plot yield in sesame crop. To minimize this yield gap, and to improve the productivity and profitability of this crop, effective training programmes and demonstrations can be conducted in the cluster village approach for encouraging the farmers to adopt the recommended technology. Overall, the present study underlines the serious need to focus on dissemination of recommended production technology of sesame crop to improve its productivity which will ultimately enable the resource-poor farmers to earn handsome livelihood on a sustainable basis.

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