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UG Thakare
Senior Scientist and Head, Krishi Vigyan Kendra, Akola, Maharashtra, India

KM Deshmukh
SMS Agronomy, Krishi Vigyan Kendra, Akola, Maharashtra, India

SV Pawar
Young Professional I, Special Project on Cotton, KVK Akola, Maharashtra, India

Corresponding Author:
KM Deshmukh
SMS Agronomy, Krishi Vigyan Kendra, Akola, Maharashtra, India

Impact of cluster front-line demonstration on soybean

UG Thakare, KM Deshmukh and SV Pawar

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Abstract
This study evaluates the impact of Cluster Frontline Demonstrations on Oilseeds (CFLDs) in improving soybean productivity and farmer adoption of enhanced technologies in the Akola district, from 2019-20 to 2023-24. A total of 275 demonstrations were conducted using the high-yielding MAUS-158 soybean variety. The results showed a significant increase in soybean yield under CFLDs, averaging 1899.2 kg/ha compared to the local check's 1467 kg/ha, representing a 22.82% increase. The yield improvement ranged from 14.82% to 33.16% over the local check across the study period. The average technology gap was 925.8 kg/ha, while the extension gap averaged 352.2 kg/ha. The technology index averaged 32.77%, indicating the feasibility and adoption potential of the demonstrated technology, with a decreasing trend suggesting growing farmer motivation to adopt improved practices. Economically, CFLDs yielded higher mean gross returns (₹72,449/ha) and net returns (₹46,508.9/ha) with a favourable benefit-cost ratio of 1.8 compared to farmer's traditional practices (1.23). These improvements were attributed to the adoption of improved MAUS-158 variety and timely, scientifically monitored cultivation practices. The study concludes that CFLDs effectively bridge the yield gap and enhance profitability, recommending their wider implementation under expert supervision for broader dissemination of improved soybean cultivation technologies and potential for on-farm seed multiplication.

Keywords: Cluster front line demonstration (CFLD), soybean, oilseeds, yield increase, technology gap

Introduction
India ranks as the world's fourth-largest producer of oilseeds, contributing about 10% to global output and covering nearly 20% of the total cultivated area. Despite this, oilseeds, which make up 10% of agricultural commodity value and 3% of India's GDP, often face unstable yields due to being grown in arid regions with poor soil and inconsistent rainfall. Traditional varieties haven't significantly boosted output, and the lack of advanced, high-yielding varieties (HYVs) exacerbates this issue. Farmers are also reluctant to adopt new cultivars because they require expensive herbicides and fertilizers, leading to stagnant yields in most oilseed crops. Soybean is predominantly grown as a rainfed crop covering the states of Madhya Pradesh, Maharashtra and Rajasthan; on vertisols and associated soils. Severe variations across time and space serve as a major constraint to the successful cultivation of soybean and achieving higher productivity, along with the influence of technology adoption levels and other factors (Verma *et al.*, 2021) [11].
Soybean stands out as a unique crop, being both an oilseed and a legume. It's the world's leading oilseed crop, contributing almost 25% of global oil production and offering high-quality protein (40%) and oil (20%) (Basediya *et al.*, 2020 & 2023) [2, 1]. It also provides essential nutrients like amino acids and lysine, often lacking in cereals. Despite its potential, variable rainfall significantly hinders successful soybean cultivation and higher productivity, alongside other factors like technology adoption. Over the past four decades, soybean has seen remarkable expansion in India, becoming the number one oilseed crop, covering 11.33 million hectares with an estimated production of 13.79 million tonnes and a productivity of 1217 kg per hectare (DA&FW, 2022) [3].
India faces a substantial demand-supply imbalance in vegetable oil, necessitating significant imports. In 2021, India imported around 13.35 million tonnes of edible oils worth ₹1,17,000 crore, fulfilling 60% of its overall demand. In soybean, a yield gap of more than 22% was observed between demonstration plots and farmers' practices during 2016-17. While the varietal replacement rate for soybean (varieties less than 10 years old) is currently 78%, further

improvement is needed.

To address these challenges, Cluster Frontline Demonstrations on Oilseeds (CFLDs) were initiated to boost productivity and gather direct feedback from farmers. These demonstrations help understand crop limitations and potential in specific areas, raise awareness, and encourage farmers to adopt better cultivation methods. This effort also aims to introduce farmers to productive new soybean varieties and recommended practices, including production and protection technologies. By embracing newer technologies, farmers can replace outdated practices and reduce the technical gap.

Materials and Methods

The present study was carried out through cluster frontline demonstrations (CFLDs) on soybean conducted by Krishi Vigyan Kendra, Akola during 2019–20 to 2023–24. A total of 275 demonstrations were laid out on farmers' fields using the improved soybean variety MAUS-158. Data on yield and economic parameters were collected both from demonstration plots and local check plots. These included grain yield, cost of cultivation, net returns, and benefit–cost ratio. Beneficiary farmers were selected to ensure equal representation, and information was obtained through direct interaction with them. The data collected were systematically organized, tabulated, and evaluated based on mean, percentage, and ranking in line with the study objectives. Moreover, the extension gap, technology gap, and technology index were estimated using the methodology proposed by Samui *et al*. (2000) [7].

Extension gap (qha^{-1}) = Demonstration yield – Farmer's yield

Technology gap (qha^{-1}) = Potential yield – Demonstration yield

Technology index (%) = [Potential yield – Demo yield / Potential yield] x 100

Benefit: cost = Gross return - Gross cost

Results and Discussion

Soybean seed yield

A comparison of productivity levels between frontline demonstrations and local checks is presented in Table 1. The results clearly indicate that soybean yield under demonstration plots remained consistently higher than that of local checks during all the study years (2019–20 to 2023–24). The yield obtained from demonstrations ranged from 1770 to 2130 kg ha^{-1}**,** reflecting a 14.82% to 33.16% increase over the local checks due to technological interventions. Year-to-year fluctuations in yield were mainly influenced by soil moisture status, variability in rainfall, sowing time, and pest and disease incidence. These findings are in line with earlier reports by Basediya *et al*. (2023) [1] and Singh *et al*. (2024) [9]. Similarly, Garud *et al*. (2022) [4] also documented that adoption of improved technologies resulted in significantly higher seed yields compared to farmers' practices under rainfed conditions.

Extension gap and Technology *gap*

To assess yield gaps, the yield achieved under frontline demonstrations was compared with the crop's potential yield, and these gaps were further categorized into technology gap and extension gap. The technology gap denotes the difference between the potential yield and the yield recorded in demonstrations with an average gap of 925.8 kg ha^{-1} observed (Table 2). This gap may be attributed to variations in soil fertility, salinity, irregular rainfall, and other climatic limitations existing at the demonstration sites. The adoption of modern agricultural technologies and high-yielding crop varieties is playing an increasingly important role in narrowing the extension gap. As farmers begin to embrace these improved agro-techniques, there is a gradual shift from traditional crop varieties to more advanced ones. However, the existing technology gap can largely be connected to differences in soil fertility, climate variability, and inadequate water management such as insufficient irrigation during dry spells or poor drainage in areas prone to heavy rainfall, particularly during critical stages of crop growth and harvest. To address these challenges, it is essential to develop and promote region-specific recommendations for both crop varieties and cultivation practices. Such tailored approaches can help minimize the yield gap under diverse environmental conditions. These observations align with the results of Vijaya Laxmi *et al*. (2020), who found similar trends in soybean cultivation.

Technology Index

The technology index reflects the practicality of the developed technology under farmers' field conditions; a lower technology index value indicates higher feasibility of the technology. The data on technology index value was observed, 34.62, 31.33, 24.60, 37.35 and 35.96 from year 2019-20 to 2023-24 respectively, with an average technology index of 32.77%, this may be attributed to irregular and unpredictable rainfall and weather conditions of the area. The decreasing trend clearly indicates that farmers are being motivated to adopt the recommended technology in their demonstrations. These results are similar to the findings of Basediya *et. al*., (2023) [1]. Lower technology index was facilitated by timely, need-based guidance from KVK scientists and extension workers, along with favorable climatic conditions and minimal pest and disease incidence. These findings were in conformity with Shaktawat *et. al*., (2021) [8] and Sri *et. al*., (2022) [10] in soybean crop.

Economic Return

Under improved technologies, soybean CFLDs gave higher mean gross returns (Rs. 72449/ha) and net returns (Rs. 46508.9/ha) with a higher B: C ratio (1.8) as compared to farmers practice (Table 3). This yield advantage could be attributed to the timely execution of crop management practices and the adoption of improved technologies under scientific supervision in demonstrations, compared to the conventional practices followed by farmers. Similar results were also reported by Vijaya Laxmi *et al*. (2020) in soybean.

Table 1: Yield and yield difference of Soybean under front line demonstration

Year	No. of FLDs	Yield (Kg/ha)		Additional yield over local check	% increase yield over local check
		FLD	Local check		
2019	50	1847	1524	323	21.19
2020	100	1940	1080	860	14.81
2021	75	2130	1975	155	33.16
2022	25	1770	1315	455	19.39
2023	25	1809	1441	368	25.54
Mean		1899.2	1467	432.2	22.82

Table 2: Yield gap and technology index in front line demonstration

Year	No. of FLDs	Technology Gap (Kg/ha)	Extension Gap (Kg/ha)	Technology Index (%)
2019	50	978	323	34.62
2020	100	885	160	31.33
2021	75	695	655	24.60
2022	25	1055	255	37.35
2023	25	1016	368	35.96
Mean		925.8	352.2	32.77

Table 3: Economics of frontline demonstration

Year	Cost of cultivation (Rs. /ha)		Gross return (Rs. /ha)		Net return (Rs. /ha)		B:C Ratio	
	Demo.	**Check**	**Demo.**	**Check**	**Demo.**	**Check**	**Demo.**	**Check**
2019	31500	30347	90355.24	72454.08	58855.24	42107.08	1.87	1.39
2020	22800	22349	63835	53970	41035	31621	1.80	1.41
2021	23658	31563	72398.7	67130.25	48740.7	35567.25	2.06	1.13
2022	24312	26780	65467	58786.5	41155	32006.5	1.69	1.20
2023	27430.4	30693.3	70189.2	62910.8	42758.76	32217.52	1.56	1.05
Mean	25940.1	28346.5	72449.0	63050.3	46508.9	34703.9	1.80	1.23

Conclusion
In Cluster Frontline Demonstrations (CFLDs), soybean yield recorded an average increase of 22.82% (1899.2 kg ha^{-1}) compared to the farmers' practice **(**1467 kg ha^{-1}). The higher mean benefit-cost ratio **(**1.8**)** encouraged farmers to adopt improved production technologies, particularly the replacement of local varieties with high-yielding cultivar MAUS-158. With the guidance of extension personnel, such demonstrations can be effectively carried out on farmers' fields to accelerate the spread of these technologies to adjoining areas. Farmers may also engage in on-farm seed multiplication, ensuring availability of quality seed for subsequent seasons while lowering the expense on seed procurement. Consequently, the yield gap can be narrowed, and soybean cultivation can become more profitable through large-scale dissemination of improved practices backed by frontline demonstrations and suitable technological support.

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