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Role of Cluster Frontline Demonstrations in Enhancing Production and Productivity of Pulses in Maharashtra: An Empirical Analysis

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ABSTRACT

Background: Crop diversification plays a crucial role in ensuring agricultural sustainability and food security. In Maharashtra, pulses form an integral part of the cropping system, particularly in Marathwada and Vidarbha regions. The study explores crop diversification trends, with a specific focus on pulses' area, production and yield. Additionally, it examines the impact of Cluster Frontline Demonstrations (CFLD) on pulses, a program initiated in 2015-16 to promote technology adoption and enhance pulse production.

Methods: The study employs a secondary data analysis approach, covering the period from 2009-10 to 2019-20. Data on pulse area, production and productivity across Maharashtra were analyzed. The simpson index of diversification (Sd) was used to assess crop diversification trends, while the impact of CFLD Pulses on technology adoption and production was evaluated through regional comparisons.

Result: Maharashtra exhibited regional disparities in pulse cultivation, with Marathwada and Vidarbha having the largest cultivation areas. Pulse production showed a consistent increase, with Vidarbha emerging as the leading pulse-producing region. The CFLD Pulses program contributed significantly to production growth, particularly in Marathwada and Vidarbha, improving productivity across all regions. The Simpson index of diversification showed an upward trend, increasing from 0.65 in 2010-11 to 0.74 in 2019-20, indicating a positive shift in diversification. Regional analysis showed stable diversification in Vidarbha, increased diversification in Western Maharashtra and declined diversification in Konkan between 2010-11 and 2019-20. Despite a decline in CFLD numbers between 2017-18 and 2021-22, the program significantly impacted technology adoption and expanded the area under pulse cultivation.

Key words: CFLD, Crop diversification, Impact study, Pulses, Regional analysis.

INTRODUCTION

Indian agriculture has grown substantially in recent decades, contributing to national food security. However, the pressing challenge for the country and its agriculture sector is to sustain this growth while ensuring nutritional security. Pulses play a pivotal role in this context, serving as a major source of protein for various segments of the population, including the poor, backward classes and the traditionally vegetarian populace (Valamoti *et al.,* 2011; Murugananthi *et al.*, 2024). Often referred to as the "Poor man's meat" and the "Rich man's vegetable," pulses are rich in proteins, vitamins and minerals, significantly contributing to the country's nutritional security (Darai *et al.,* 2021; Singh *et al.*, 2022). Pulses represent a group of crops that offer high-quality protein, complementing the cereal protein intake for the predominantly vegetarian population in India (Ali and Gupta, 2012). This makes pulse production a cost-effective alternative to animal protein. Despite being the world's largest pulse-cultivating nation, India's pulse production lags behind cereal crops. Cultivating pulses also benefits the environment by fixing atmospheric nitrogen in their root nodules, reducing the need for external nitrogen resources. Pulses have several advantages, including their rich protein content, affordability, suitability for intercropping and resilience to rainfed conditions, requiring minimal irrigation. These factors make pulses a preferred choice for cultivation in areas left after fulfilling the demand for cereals and cash crops, offering attractive returns on investment (Singh *et al.,* 2019). Furthermore, pulses contribute to soil fertility improvement and erosion control and serve as valuable fodder for cattle.

India is prominent in the global pulse market, being the largest producer (25.00 per cent) and consumer (27.00 per cent) of total pulses. The frequency of pulse consumption in the country surpasses other protein sources, underscoring their importance in daily diets. Total Pulse

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production during 2022-23 is estimated at 260.58 Lakh tonnes, higher by 14.02 Lakh tonnes than the average pulse production during the last five years, which was 246.56 Lakh tonnes (GoI, 2022-23). Key pulse-producing states such as Rajasthan, Madhya Pradesh, Maharashtra, Uttar Pradesh, Karnataka, Gujarat and Andhra Pradesh accounted for over 80.00 per cent of the total pulse area. They contributed nearly 83.00 per cent to the total production.

To meet the projected demand of 32 million tons of pulses by 2030, a growth rate of 4.20 per cent is imperative. Achieving this requires a transformative approach in research, technology development, dissemination and the adoption of improved crop management practices, accompanied by capacity building in research areas (Tiwari and Shivhare, 2017). Recognizing the significance of this challenge, the Ministry of Agriculture and Farmers Welfare, Government of India, launched a nationwide Cluster Frontline Demonstration (CFLD) program on pulses under the National Food Security Mission-Pulses (NFSM-Pulses) in the year 2015-16. This initiative aims to promote improved pulse farming technologies, including seeds, micro-nutrients, soil amendments, weed and pest management, farm machinery–and micro-irrigation devices, while also enhancing farmers' capacity.

The ICAR, through its krishi vigyan kendras (KVKs) spread across the country, has been actively implementing the CFLD program on various pulse crops, focusing on boosting pulse production and productivity using improved varieties and location-specific technologies. In Maharashtra, the CFLD pulses program, implemented by 44 KVKs in 2021, covered 1640 ha, benefiting 4100 farmers. Demonstrations included improved varieties, integrated pest management (IPM), integrated nutrient management (INM), seed treatment and bio-fertilizers. Notable results were achieved, such as increased yields of pigeon pea, green gram, black gram, chickpea, cowpea, horse gram–and dolichous bean during the kharif and rabi seasons, contributing to the enhancement of pulse cultivation in the state.

Crop diversification refers to a shift from the regional dominance of one crop to the regional production of several crops. Diversification in cropping choice decreases the overall production risk by selecting a mix of crops with a low or negative correlation in their productivity. The direction of crop diversification is also a matter of research interest. Diversification of crops enhances cropping intensity and productivity growth (Bobojonov *et al.,* 2012). In India, the degree of diversification exhibits huge variations among different regions (Radhakrishna and Panda, 2006). Identifying patterns and degrees of crop diversification is imperative in formulating region-specific agriculture development strategies. With this background, an attempt has been made to examine the status of crop diversification in Maharashtra. Similarly, an attempt has been made to study the impact of CFLD pulses programme on area, production and yield in Maharashtra.

MATERIALS AND METHODS

The present study is based on the secondary data (2009-10 to 2019-20) on land area statistics published by the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India. The crops group for the study includes cereals and millet, pulses, oilseeds and commercial crops. The simpson index of diversification (Sd) is estimated for the entire crop sector and crop sub-sectors from 2010-11 to 2019-20. Simpson Index of crop diversification (Sd) is used to assess the degree of crop diversification. The index is estimated using the following formula:

$$sd = 1 - \sum_{i=1}^{n} p_i^2$$

Where,

Pi = Proportion of ith crop/crop sector in the gross cropped area.

The diversification index ranges between 0 and 1. Higher values indicate high degree of crop diversification (Singh *et al.,* 1984).

Data on number of demonstrations and areas covered under CFLD Pulses was obtained from 44 KVKs of Maharashtra. Further, information on local yield, demonstration yield, cost and returns was compiled from various annual reports of ICAR-ATARI, Pune. Observations recorded during cluster front-line demonstrations were considered while studying the impact. For regional analysis, Maharashtra has been divided into five regions and districts under each region is given below.

Region-wise classification of districts of Maharashtra.

Regions	Districts
Marathwada	Aurangabad, Beed, Hingoli, Jalna, Latur, Nanded, Osmanabad and Parbhani
Vidarbha	Akola, Amravati, Bhandara, Buldhana, Chandrapur, Gadchiroli, Gondia, Nagpur, Wardha, Washim and Yavatmal
Konkan	Palghar, Raigadh, Ratnagiri, Sindhudurg and Thane
Western Maharashtra	Kolhapur, Pune, Sangli, Satara and Solapur
Khandesh	Ahmednagar, Dhule, Jalgaon, Nandurbar and Nashik

RESULTS AND DISCUSSION

Scenario of crop diversification in Maharashtra

As the Ministry of Agriculture and Farmers Welfare, Government of India had initiated a nation-wide CFLD programme on pulses under NFSM-Pulses during 2015-16, two time periods, *i.e.* 2010-11 and 2019-20, have been selected to analyse the impact of the programme on the pattern of crop diversification, especially on area coverage under pulses in the state of Maharashtra. Table 1 describes

the region-wise Simpson indices of Maharashtra for 2010-11 and 2019-20. The Simpson Index of Diversification (Sd) is estimated for the primarycrop sector and crop sub-sectors for the period 2010-11 and 2019-20. The diversification index ranges between 0 and 1. Higher values indicate a high degree of crop diversification. In the case of Maharashtra, the Simpson Index has increased from 0.65 to 0.74 between 2010-11 and 2019-20, which indicates that the degree of crop diversification has increased significantly during the same period. The findings from the study are corroborated by previous research conducted by Kumar and Gupta, (2015).

The simpson index of the Western Maharashtra region has increased significantly from 0.42 (2010-11) to 0.60 (2019-20). It was observed that in Western Maharashtra, the area under pulse has increased from 0.41 mha to 0.44 mha between 2010-11 to 2019-20, In contrast, area under cereals and millets has decreased drastically from 4.2 mha to 1.91 mha, similarly the area under oilseed has decreased from 0.42 mha to 0.38 mha during the same period. At the same time, the Konkan region has shown a decline in the degree of crop diversification during the study period. The Simpson indices for Marathwada and Khandesh regions have increased from 0.69 and 0.55 to 0.74 and 0.66 during 2010-11 and 2019-20, respectively. It was observed that in case of Marathwada, pulse area increased from 1.43 mha to 1.56 mha. Similarly, the area under oilseed has increased from 1.18 mha to 1.80 mha during the same period. At the same time, area under cereals and millets has decreased drastically from 3.62 mha to 1.34 mha. Vidarbha region has shown a stagnant degree of crop diversification during the same period. A stagnant degree of crop diversification does not indicate any changes in cropping choice. Data revealed that in the case of the Vidarbha region, there was increased area coverage under pulses (1.56 m ha: 2010-11 to 1.60 m ha: 2019-20) and under oilseed (1.67 m ha to 2.03 m ha), whereas area under cereals and millets has decreased drastically 1.89 mha to 1.36 mha during the same period.

Table 1: Region-wise Simpson indices of Maharashtra.

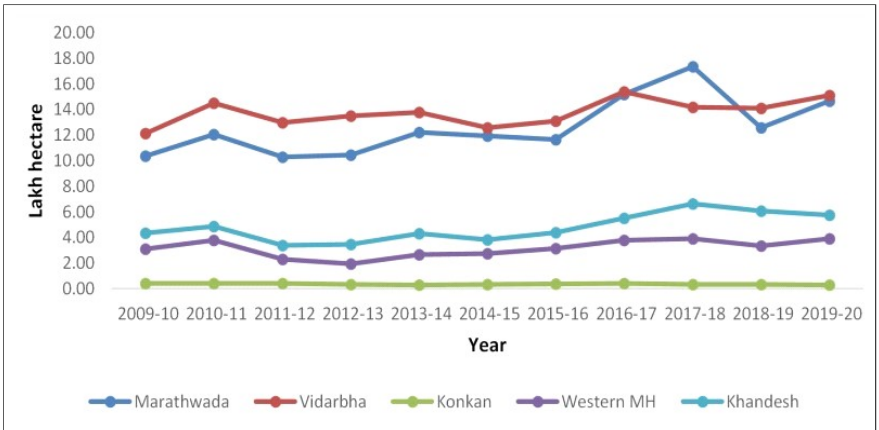
Regions	2010-11	2019-20
Marathwada	0.69	0.74
Vidarbha	0.75	0.75
Konkan	0.20	0.16
Western Maharashtra	0.42	0.60
Khandesh	0.55	0.66
Overall	0.65	0.74

Source: Author's calculation based on information from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India.

An overview of area, production and yield of pulses in Maharashtra

Region-wise area coverage under pulses in Maharashtra from 2009-10 to 2019-20 is shown in Fig 1. Marathwada and Vidarbha regions have the higher area coverage under pulses in Maharashtra during the same period. As a significant rice-producing area, the Konkan region has the least area coverage under pulses in Maharashtra. Marathwada region achieved the highest area coverage, with 17.33 lakh hectares under pulses during 2017-18. Western Maharashtra and Khandesh regions have shown an increasing trend in pulses area. In the Khandesh region, the area under pulses has increased from 4.32 lakh hectares in 2009-10 to 5.76 lakh ha in 2019-20, whereas it has increased from 10.34 lakh ha to 15.07 lakh ha in the Marathwada region during the same period. These results are consistent with previous research findings of Lakshmi *et al.* (2020).

The pulse production in Maharashtra from 2009-10 to 2019-20 has shown an increasing trend across the regions (Fig 2). During the same period, Vidarbha region had the highest pulses production, followed by Marathwada, Khandesh and Western Maharashtra regions. Being the major pulse-producing regions, Marathwada (18.22 lakh tons) and

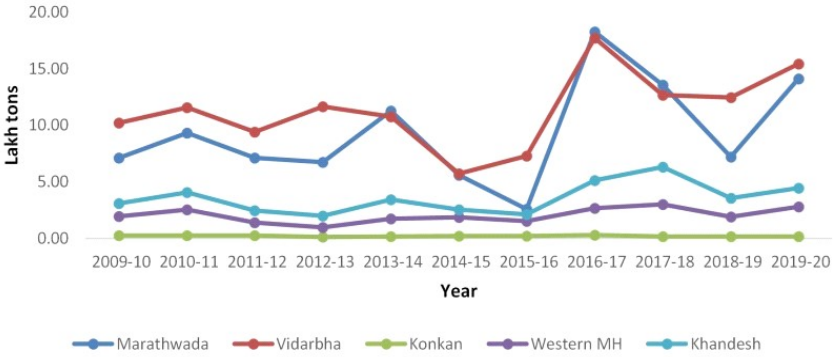


(Source: Author's calculation based on information from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India).

Fig 1: Area under pulses in Maharashtra (lakh ha).

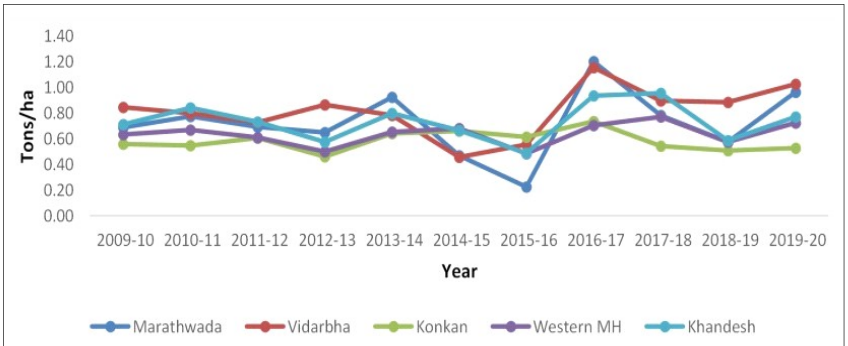
Vidarbha (17.70 lakh tons) regions have shown a significant increase in production in the year 2016-17, which may be due to the impact of implementation of the programme CFLD Pulses under NFSM during 2015-16. In Marathwada region, production under pulses has increased from 7.11 lakh tons in 2009-10 to 14.11 lakh tons in 2019-20, whereas it has increased from 10.22 lakh tons to 15.42 lakh tons during the same period in Vidarbha region.

Fig 3 clearly shows the impact of the CFLD Pulses programme on pulse productivity across all of Maharashtra's regions. The productivity of pulses has increased significantly between 2015-16 and 2016-17, which may be due to the adoption of high-yielding varieties following advanced farming practices under the CFLD Pulses programme in the state. Pulse's productivity has increased between 2009-10 and 2019-20 across the regions. The



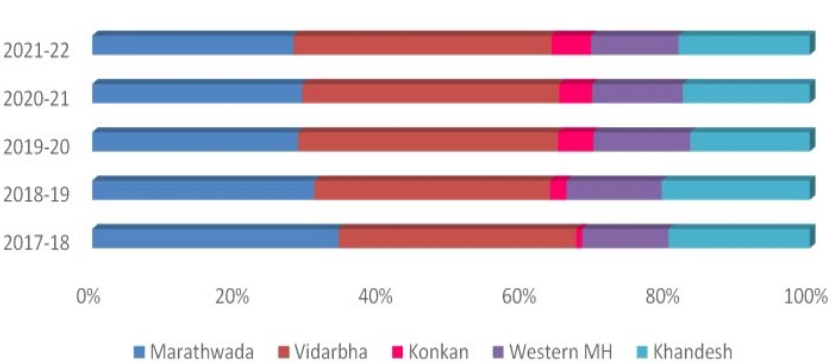
(Source: Author's calculation based on information from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India).

Fig 2: Pulses production in Maharashtra.



(Source: Author's calculation based on information from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India).

Fig 3: Productivity of pulses in Maharashtra.



(Source: Author's calculation based on various Annual Reports of ATARI, Pune).

Fig 4: Demonstrations under CFLD Pulses in Maharashtra.

highest productivity of 1.20 tons per hectare was experienced by the Marathwada region followed by the Vidarbha region (1.15 tons per hectare) during 2016-17. In the Vidarbha region, productivity under pulses has increased from 0.84 tons per hectare in 2009-10 to 1.02 tons per hectare in 2019-20. In contrast, yield has increased from 0.69 to 0.96 tons per hectare during the same period in the Marathwada region.

Status of demonstrations under CFLD on pulses in Maharashtra

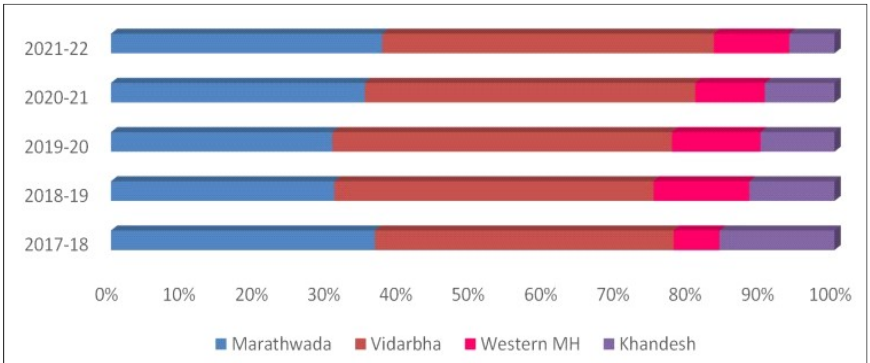
From the regional analysis, it was found that the Vidarbha region has a significant share in the total number of demonstrations in Maharashtra, it was followed by Marathwada and Khandesh regions between 2017-18 and 2021-22 (Fig 4).

During 2017-18, 2050 demonstrations were conducted in the Marathwada region, whereas 1975, 1175 and 718 demonstrations were conducted in Vidarbha, Khandesh and Western Maharashtra regions Between 2017-18 and 2021-22, the Western Maharashtra region conducted less than fifteen per cent of the total demonstrations under CFLD on pulses in Maharashtra, but their percentage share has increased over the years. During 2021-22, 1475 demonstrations were laid out in Vidarbha region, whereas 1150, 750 and 500 demonstrations were conducted in Marathwada, Khandesh and Western Maharashtra regions (Table 2). Even though the number of demonstrations decreased from 2017-18 (5968) to 2021-22 (4100) in Maharashtra, due to the intervention of CFLD programme, area under pulses has increased under new technologies, which has lead to higher productivity and production in the state of Maharashtra.

Status of pigeon pea demonstrations under CFLD on pulses in Maharashtra

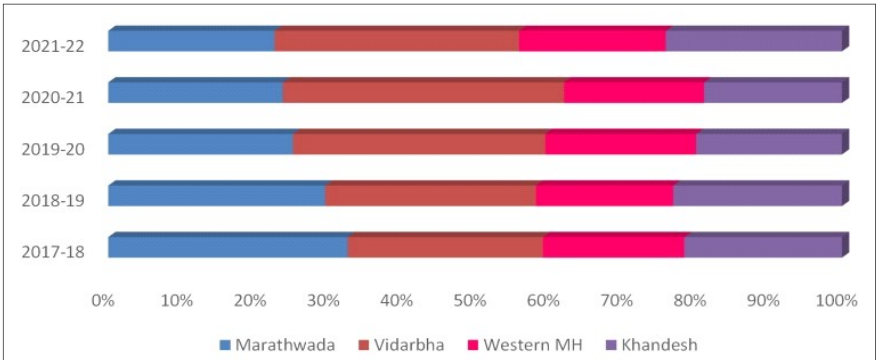
Vidarbha region has a significant share in the total number of pigeon pea demonstrations in Maharashtra (>40%) followed by Marathwada (>30%) region between 2017-18 and 2021-22 (Fig 5).

Results show that 650 demonstrations were conducted in the Vidarbha region, whereas 575, 250 and 100 demonstrations were conducted in Marathwada, Khandesh and Western Maharashtra regions, respectively, during 2017-18. Between 2017-18 and 2021-22, the Western Maharashtra region conducted less than 15% of the total pigeon pea demonstrations under CFLD on pulses in Maharashtra. During 2021-22, a total of 1200 demonstrations were conducted on farmers' fields, out of which 550 were conducted in the Vidarbha region, whereas 450 and 125 were conducted in the Marathwada and Western Maharashtra regions, respectively (Table 3).



(Source: Author's calculation based on various Annual Reports of ATARI, Pune).

Fig 5: Pigeon pea demonstrations under CFLD Pulses in Maharashtra.



(Source: Author's calculation based on various Annual Reports of ATARI, Pune).

Fig 6: Chick pea demonstrations under CFLD Pulses in Maharashtra.

Table 2: Number of demonstrations under CFLD Pulses in Maharashtra.

Regions	2017-18	2018-19	2019-20	2020-21	2021-22
Marathwada	2050	2025	1250	1115	1150
Vidarbha	1975	2150	1575	1365	1475
Konkan	50	150	215	175	225
Western Maharashtra	718	869	588	481	500
Khandesh	1175	1350	725	675	750
Total	5968	6544	4353	3811	4100

(Source: Author's calculation based on various Annual Reports of ATARI, Pune).

Table 3: Number of demonstrations on pigeon pea under CFLD Pulses in Maharashtra.

Regions	2017-18	2018-19	2019-20	2020-21	2021-22
Marathwada	575	525	375	365	450
Vidarbha	650	750	575	475	550
Western Maharashtra	100	200	150	100	125
Khandesh	250	200	125	100	75
Total	1575	1675	1225	1040	1200

(Source: Author's calculation based on various Annual Reports of ATARI, Pune).

Table 4: Number of demonstrations on chick pea under CFLD pulses in Maharashtra.

Regions	2017-18	2018-19	2019-20	2020-21	2021-22
Marathwada	950	900	475	475	425
Vidarbha	775	875	650	765	625
Western Maharashtra	561	560	388	381	375
Khandesh	625	700	375	375	450
Total	2911	3035	1888	1996	1875

(Source: Author's calculation based on various Annual Reports of ATARI, Pune).

Status of chick pea demonstrations under CFLD on pulses in Maharashtra

Chickpea demonstrations under CFLD on pulses in Maharashtra were conducted between 2017-18 and 2021-22. Fig 6 indicates that the Vidarbha region has the major share (34.00 per cent) in the total number of demonstrations in Maharashtra, it was followed by the Marathwada (25.00 per cent) and the Khandesh (22.00 per cent) regions.

During 2017-18, 950 demonstrations were conducted in Marathwada region, whereas 775, 625 and 561 demonstrations were laid out in Vidarbha, Khandesh and Western Maharashtra regions. Between year 2017-18 and 2021-22, Konkan region conducted less than five per cent of the total chickpea demonstrations under CFLD on pulses in Maharashtra due to low cropped area under the crop. During 2021-22, 625 demonstrations were held in the Vidarbha region, whereas 450, 425 and 375 demonstrations were organized in Khandesh, Marathwada and Western Maharashtra regions (Table 4).

CONCLUSION

CFLD on pulses program has played a significant role in diversifying the area under cultivation towards pulses across all regions (except Konkan) in Maharashtra state. The impact of CFLD Pulses programme was reflected through the increase in degree of crop diversification across different regions of Maharashtra. Between 2017-18 and 2021-22, despite a decrease in the number of cluster frontline demonstrations (CFLDs), the CFLD Pulses program demonstrated a remarkable impact, leading to increased technology adoption and expanded pulse cultivation areas among farmers. The regional analysis helped to identify the priority areas where we can encash the opportunity to expand the area of the pulses under non-conventional pulse-growing regions. Technical feedback on demonstrated technology may be recorded and informed to the concerned institution for further information. The cluster approach for pulses demonstrations proved highly effective and useful in villages, facilitating a swift and efficient transfer of agricultural technologies. Additionally, identifying technologies from ICAR institutes/ SAUs suitable for climatic vulnerability situations and integrating them into the CFLD action plan enhances the program's resilience and adaptability. Instances, where farmers achieved higher yields under demonstrations compared to potential yields in pulse crop cultivars, should be thoroughly studied to discern the factors contributing to these commendable results.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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