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Knowledge and Adoption of Chickpea Cultivation Technologies under Cluster Front Line Demonstrations among Farmers of Bikaner, Rajasthan

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Authors' contributions

This work was carried out in collaboration among all authors. Author OPC designed the study, performed the statistical analysis and wrote the first and final draft of the manuscript. Author RKV designed the study, wrote and reviewed the first and final draft of the manuscript. Author AKS managed the analyses. Author RSC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The impact of the Cluster Front Line Demonstration (CFLD) program—implemented by KVK Bikaner-I under the National Food Security Mission in the arid region of Bikaner, Rajasthan was assessed to determine its influence on farmers' uptake of improved chickpea cultivation practices. A total of 200 growers (100 CFLD participants and 100 non-participants) were drawn by proportionate random sampling from Bikaner and Kolayat tehsils. Data were collected through structured interviews, standardized knowledge tests, and adoption checklists to capture two dependent measures (knowledge level and extent of adoption) alongside eleven independent variables: age, caste, education, social participation, occupation, landholding, irrigation source, mass-media exposure, extension-agency contact, information-seeking behaviour, and information-sharing behaviour. Descriptive analysis showed that beneficiaries held larger average land parcels (5.45 ± 1.38 ha) and scored higher on—mass-media exposure (19.54 ± 6.07) and extension contact (18.66 ± 6.72)—than non-beneficiaries. Mean knowledge and adoption scores were significantly greater among CFLD participants. Pearson's correlation revealed strong positive associations between both knowledge and adoption and four communication factors (mass-media exposure, extension contact, and information-seeking and sharing behaviours; $r > 0.52$, $p < .01$), and moderate positive links with education ($r \approx 0.47–0.66$, $p < .01$). Age exhibited a small negative correlation ($r \approx –0.24$, $p < .05$). Caste and social participation showed weaker yet significant relationships with knowledge among beneficiaries ($r \approx 0.24–0.29$, $p < .05$). Overall, participation in CFLD was associated with higher knowledge and technology adoption, underscoring the program's effectiveness in technology diffusion. It was concluded that proactive communication and targeted training drove these gains. Future extensions should focus on including non-participant cohorts particularly the older and less-educated farmers by intensifying digital and mass-media outreach, strengthening peer-learning networks, and institutionalizing follow-up visits to sustain technology uptake and enhance chickpea productivity in arid agro-ecosystems.

Keywords: Chickpea; CFLD; knowledge level; technology adoption; extension contact; mass-media; information behavior and Rajasthan.

1. INTRODUCTION

The increasing population and evolving dietary patterns in India have led to an escalating demand for pulses, which are essential for ensuring food security and providing a critical source of protein, particularly for the vegetarian population. Pulses, including chickpea (*Cicer arietinum*), are not only a key dietary staple but also contribute to soil health through their nitrogen-fixing capabilities, thus support sustainable agricultural practices. Despite their vital role in both human nutrition and environmental sustainability, the per capita availability of pulses has significantly declined over the decades, and the current production levels are insufficient to meet the rising domestic demand (Singh et al., 2020). This gap in production has led to a growing concern regarding how to enhance pulse cultivation, particularly in the context of India's largest pulse-producing states like Rajasthan (Kumari *et al.,* 2023). With the changing agricultural landscape and the need for effective extension systems, front-line demonstrations and cluster-based interventions, such as the Cluster Front Line Demonstration (CFLD) program, have become essential tools for promoting the adoption of advanced cultivation technologies among farmers. The CFLD program, initiated in 2015 under the National Food Security Mission, has been instrumental in disseminating new technologies to farmers, especially in rainfed regions. However, the effectiveness of these demonstrations in improving farmers' knowledge and adoption rates remains an area requiring requires further investigation. Recent evaluations of CFLD across India have showcased significant improvements in crop productivity and farmer incomes. In the Sirohi district of Rajasthan, CFLDs on mustard over three years (2020–2023) resulted in an average yield increase of 26.47 per cent compared to traditional practices (). Similarly, in Shivpuri district of Madhya Pradesh, chickpea demonstrations over five years reported yield enhancements ranging from 25.22 per cent to 47.32 per cent with a benefit-cost ratio between 2.86 and 4.41 (). In Peddapalli district, Telangana, red gram CFLDs achieved an average yield of 13.35 quintals per hectare, nearly doubling the 7.04 quintals per hectare from traditional methods, and increased net

returns from ₹14,302 to ₹50,491 per hectare (). These studies affirm the effectiveness of CFLDs in bridging yield gaps and enhancing profitability for farmers

Several studies emphasize several key factors influence the knowledge levels and adoption of agricultural technologies among farmers. Education consistently emerges as a significant factor. Badhala (2012) and Meena et al. (2012) found that a higher level of education is positively associated with better knowledge of agricultural practices, which leads to greater adoption of improved technologies. Similarly, social participation plays a crucial role in enhancing knowledge and adoption rates, as highlighted by Chodavadia et al. (2014) and Meena and Sharma (2019). Farmers who engage in social groups or community activities are more likely to adopt innovative agricultural practices due to enhanced knowledge-sharing opportunities and a stronger network for information exchange.

Extension participation is another key determinant of knowledge and adoption, with studies done by Raghava and Rao (2013) and Kumar and Sharma (2018) showing that farmers actively involved in extension activities, such as Frontline Demonstrations (FLDs), exhibit higher levels of adoption. Moreover, age and income are also important variables influencing adoption, with older farmers generally showing lower levels of adoption, as seen in Mandavkar et al. (2013). Conversely, higher income tends to facilitate the adoption of advanced agricultural technologies, providing farmers with the necessary resources to invest in new practices. These findings collectively underline the importance of education, social participation, extension services, and economic factors in enhancing agricultural knowledge and adoption among farmers.

The present study evaluated the impact of the CFLD program on the adoption of chickpea cultivation technologies in Rajasthan, specifically focusing on the interventions conducted by Krishi Vigyan Kendra (KVK) Bikaner-IThis study seeks to assess how the program has influenced the adoption of modern cultivation practices and the associated improvements in chickpea production in the region. The specific objectives of this study were to examine the relationship between selected socio-economic variables and the knowledge levels, as well as the extent of adoption of chickpea cultivation technologies demonstrated under CFLD. Additionally, the study will identify the challenges faced by farmers in the adoption process, providing insights that can enhance future extension efforts and contribute to the sustainable development of pulse production in Rajasthan.

2. MATERIALS AND METHODS

The study was carried out in the Bikaner district of Rajasthan, selected for its pivotal role in chickpea production within the state. Bikaner, known for its arid climate and sandy soils, presents unique challenges for agriculture, particularly in terms of water availability and soil fertility. These conditions make it an ideal location for evaluating the effectiveness of agricultural interventions such as the Cluster Front Line Demonstration (CFLD) program, which aims to introduce innovative farming practices and technologies to improve crop yields. The research specifically targeted Krishi Vigyan Kendra (KVK) Bikaner-I, which has been more active in implementing CFLD programs compared to its counterpart, KVK Bikaner-II, particularly during the period from 2016 to 2020. The study was conducted in two tehsils of the district namely Bikaner and Kolayat which were chosen for their higher concentration of CFLD participants. These areas were selected to capture a comprehensive view of the program’s reach and impact on local farming practices.

A total of 200 farmers were surveyed for the study, including 100 farmers who had benefited from the CFLD initiatives and training, and another 100 farmers who had been engaged in chickpea cultivation for at least five years but had no exposure to the CFLD program. To ensure a representative sample, the farmers were selected using proportionate random sampling from the two tehsils. Structured interviews were conducted to collect detailed data on the farming practices, challenges, and outcomes of both groups. The primary aim of the study was to assess how the extension services provided through CFLD influenced farmers' knowledge, technology adoption, and chickpea production practices, with a focus on understanding the effectiveness of these interventions in a resource-constrained environment like Bikaner. This approach allowed for a comparative analysis between the beneficiaries of the CFLD program and non-beneficiaries, providing valuable insights into the impact of agricultural innovations on improving productivity and sustainability in arid regions.

3. RESULTS AND DISCUSSION

The profile of the farmers' personal, social, and economic characteristics reveals a cohort of mid-career cultivators with sufficient land resources but limited formal social engagement. With an average age of 49.5 years (SD = 4.8), the group is largely composed of experienced adults well past entry-level, positioning them to combine traditional knowledge with new practices. Their average caste code of 3.4 (SD = 1.1) on a scale reflecting the predominance of OBC and SC categories corroborates the heavy representation of socially disadvantaged groups in the sample. Educational attainment averaged 7.5 years (SD = 2.06), indicating most have completed primary to lower secondary schooling. Yet social participation was low (mean = 0.89 on a 0–2 scale; SD = 0.14), reflecting that fewer than half engage actively in formal organizations. Economically, the average occupation score of 4.2 (SD = 0.25) suggests a stable reliance on farming as the primary livelihood, while a mean landholding of 5.45 ha (SD = 1.38) places them firmly in the semi-medium to medium-sized category. Finally, with an irrigation-source score of 2.1 (SD = 0.59 on a 1–3 scale), most farmers draw water from both canals and groundwater, smoothing seasonal variability but also indicating dependence on multiple infrastructure systems.

Communication attributes were markedly stronger and more variable, underlining their critical role in technology uptake. Mass-media exposure averaged 19.54 (SD = 6.07) on a 0–30 scale, showing that farmers generally have moderate to high access to TV, radio, and print, but with some pockets of low reach. Extension-agency contact similarly scored 18.66 (SD = 6.72), pointing to regular, though uneven, interactions with KVK and other advisors. Information-seeking behaviour (mean = 18.17, SD = 4.30) and information-sharing behaviour (mean = 18.07, SD = 4.47) both clustered around the upper half of their scales, indicating a community that is on average proactive in finding and disseminating agricultural knowledge. The comparable means and moderate SDs across these four measures suggest that while most farmers engage effectively with communication channels, targeted efforts to raise the floor—particularly among those with lower scores could further enhance collective learning and the diffusion of improved chickpea technologies.

To find out the association between selected independent variables of respondents with the dependent variable viz. knowledge and extent of adoption of CFLD, correlation analysis was done. Correlation reveals about the relationship between the two variables and the strength of relationship is measured in terms of correlation coefficient, whose limit range from minus unit to plus unit. The two variables are not correlated, it means one variable do not affect the other variable.

As per the correlation coefficient (r) analysis, the data presented in Table 1 reveals the correlation of dependent variable which is knowledge on eleven independent variables concerning to the respondents. Through correlation coefficient, data were critically examined to work with the separates as well as combined relative effect of the selected independent variables on the knowledge level of respondents about chickpea cultivation technologies demonstrated under CFLD. The correlation of all the eleven selected independent variables such as age, caste, education, social participation, occupation, land holding, source of irrigation, mass media exposure, extension agency contact, information seeking behavior and information sharing behavior used with the knowledge level of the respondents were calculated by correlation coefficient equation. The findings had been presented in Table 1. The r-values in table 1 indicated that the mass media exposure (0.738**), extension agency contact (0.645**) and information seeking behavior (0.783**) of beneficiary farmers were positively related with knowledge level of the respondents about chickpea cultivation technologies demonstrated under CFLD and association was found significant at 1% level of significance. The r-values of caste (0.243*), education (0.287*) and social participation (0.237*) of beneficiary farmers were positively and significantly related with knowledge of respondents about chickpea cultivation technologies demonstrated under CFLD and the association was found significant at 5% level of significance. Age (-0.204*) was negatively significant at 5% level of significance. Land holding and source of irrigation of beneficiary farmers showed positive whereas, occupation has negative and non-significant relation with knowledge level of the respondents about chickpea cultivation technologies demonstrated under CFLD.

Age (0.311*), caste (0.314*), occupation (0.359*), extension agency contact (0.369*) and information sharing behavior (0.311*) of non-beneficiary farmers were positively related with knowledge of respondents about improved cultivation technologies of chickpea and the

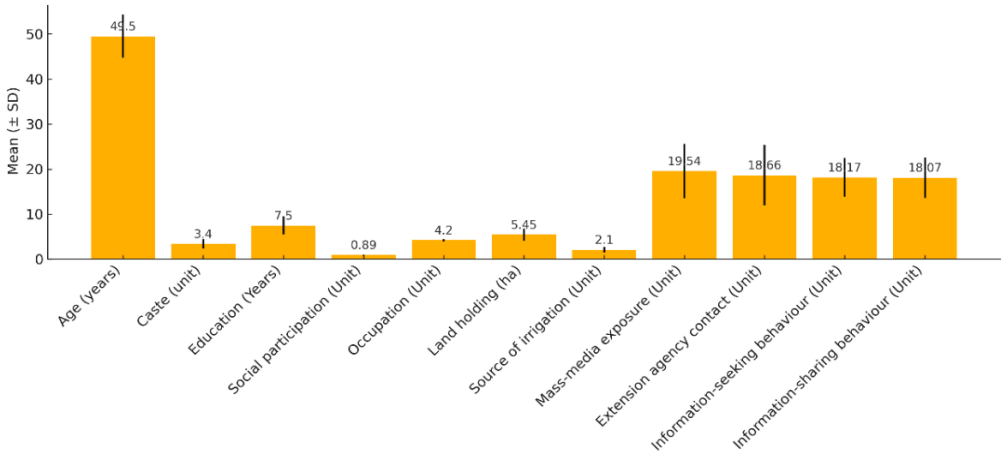

Fig. 1. Mean and Standard Deviation of Farmers Attributes

Table 1. Correlation Analysis between Independent Variables with Knowledge of farmers regarding chickpea cultivation technologies

S. No.	Variables	Correlation Coefficient (r)		
		Beneficiaries (n=100)	Non-Beneficiaries (n=100)	Overall (n=200)
A.	**Personal and Social Attributes**			
1	Age	-0.204*	0.311*	-0.372 *
2	Caste	0.243*	0.314*	0.278*
3	Education	0.287*	-0.142^{NS}	0.668**
4	Social Participation	0.237*	-0.036^{NS}	-0.112^{NS}
B.	**Economic Attributes**			
5	Occupation	-0.091^{NS}	0.359*	0.435**
6	Land Holding	0.054^{NS}	-0.025^{NS}	-0.106^{NS}
7	Source of Irrigation	0.169^{NS}	0.125^{NS}	-0.039^{NS}
C.	**Communicational Attributes**			
8	Mass Media Exposure	0.738**	-0.059^{NS}	0.524**
9	Extension Agency Contact	0.645**	0.369*	0.720**
10	Information Seeking Behaviour	0.783**	0.030^{NS}	0.536**
11	Information Sharing Behaviour	0.002^{NS}	0.311*	0.171^{NS}

*NS = Not Significant; * = Significant at 5%, ** = Significant at 1%*

Table 2. Correlation Analysis between Independent Variables with Adoption of farmers regarding chickpea cultivation technologies

S. No.	Variables	Correlation Coefficient (r)		
		Beneficiaries (n=100)	Non-Beneficiaries (n=100)	Overall (n=200)
A.	**Personal and Social Attributes**			
1	Age	-0.269*	-0.493**	-0.241*
2	Caste	-0.161^{NS}	-0.121^{NS}	0.102^{NS}
3	Education	0.470*	0.693**	0.510**
4	Social Participation	0.187^{NS}	0.033^{NS}	0.105^{NS}
B.	**Economic Attributes**			
5	Occupation	0.208*	0.445**	0.178^{NS}
6	Land Holding	0.033^{NS}	0.225*	0.333*
7	Source of Irrigation	0.148^{NS}	0.094^{NS}	-0.166^{NS}
C.	**Communicational Attributes**			
8	Mass Media Exposure	0.738**	0.369*	0.724**
9	Extension Agency Contact	0.700**	0.030^{NS}	0.651**
10	Information Seeking Behaviour	0.790**	0.093^{NS}	0.623**
11	Information Sharing Behaviour	-0.008^{NS}	0.609**	-0149^{NS}

*NS = Not Significant; * = Significant at 5%, ** = Significant at 1%*

association was found significant at 5% level of significance. The r-values of source of irrigation and information seeking behavior of non-beneficiary respondents showed positive and non-significant relation with level of knowledge of respondents about chickpea cultivation technologies. Social participation, education, land holding and mass media exposure of non-beneficiary farmers showed negative and non-significant relation with knowledge of respondents about chickpea cultivation technologies.

Further analysis of table 1 to know the relationship of selected independent variables with knowledge of overall respondents about chickpea cultivation technologies indicated that education (0.668**), occupation (0.435**), mass media exposure (0.524**), extension agency contact (0.720**) and Information seeking behavior (0.536**) of overall farmers were found positively related with knowledge level of farmers about chickpea cultivation technologies and the association was found significant at 1% level of significance.

The findings of the study are in compliance with the findings of Aravindh Kumar and Karthikeyan, (2022) and Badhala (2012) who stated that education found to be highly significant with knowledge level of the beneficiary and Bhanarkar (2019) stated that only education was found to be positive and highly significant with knowledge at one per cent level of significance while the other variable such as land holding, source of information and risk preference were found to be positively significant at five per cent level of significance.

The r-values in table 2 indicated that the mass media exposure (0.738**), extension agency contact (0.700**) and information seeking behavior (0.790**) of beneficiary farmers were positively associated with extent of adoption about chickpea cultivation technologies at 1% level of significance whereas, education (0.470*) and occupation (0.208*) of beneficiary farmers were positively associated with extent of adoption of the respondents about chickpea cultivation technologies at 5% level of significance. Age (-0.269*) was negatively significant at 5% level of significance. The r-values of social participation, land holding and source of irrigation showed positive and non-significant relation with adoption of chickpea cultivation technologies by respondents. Caste and information sharing behavior of beneficiary farmers showed negative and non-significant relation with adoption of chickpea cultivation technologies.

Similarly, education (0.693**), occupation (0.445**) and information sharing behavior (0.609**) of non-beneficiary farmers were found positively significant whereas, age (-0.493**) was found negatively significant at 1% level of significance. The r-values of land holding (0.225*) and mass media exposure (0.369*) of non-beneficiary farmers showed positively significant at 5% level of significance. Social participation, source of irrigation, extension agency contact and information seeking behavior of non-beneficiary farmers showed positively whereas, caste had negatively non-significant relation with adoption of chickpea cultivation technologies.

Further, the analysis of table 2 to determine the relationship of selected independent variables with adoption of respondents about chickpea cultivation technologies indicated that education (0.510**), mass media exposure (0.724**), extension agency contact (0.651**) and information seeking behavior (0.623**) of overall respondents found positively associated at 1% level of significance. Land holding (0.333*) was found positive but age (-0.241*) negatively and significantly associated at 5% level of significance. The r-values of caste, social participation and occupation of overall respondents also showed positive but source of irrigation and information sharing behavior showed negative and non-significant relation with adoption of chickpea cultivation technologies by respondents.

The findings of the study are in line with findings of Aravindh Kumar and Karthikeyan, (2020) and Mohite (2013) who stated education is highly significant with extent of adoption. The findings are contradictory with finding of Sharma *et al.* (2020) who stated that the age was found to be positive and significantly associated with the adoption level.

4. CONCLUSION

Farmers who participated in the CFLD program in Bikaner-I had demonstrably higher knowledge and greater adoption of chickpea cultivation technologies than non-participants, with mean knowledge and adoption scores showing significant positive correlations with education, mass-media exposure, extension-agency

contact, and information-seeking behaviour (all p < .01), while age exhibited a small but significant negative association. Beneficiary farmers also held larger land parcels and used multiple irrigation sources, yet formal social participation remained low across both groups. Overall, education and proactive engagement with information channels emerged as the strongest drivers of both knowledge acquisition and technology adoption. For future interventions, the CFLD model should be scaled up to include non-beneficiary farmers—especially older and less-educated cohorts—by integrating tailored training modules, strengthening mass-media and digital outreach, and fostering peer-learning networks to raise the floor of awareness and ensure more equitable diffusion of improved chickpea technologies.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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